WKTaDSA – 1. 16th to 20th November 2020

WKTaDSA – 2. 18th to 22nd January 2021

Preliminary assessments of megrim (*Lepidorhombus whiffiagonis*) and Four-spot megrim (*L. boscii*) in 8c9a using a4a model

By

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1 Introduction

Both southern megrims stocks *(L. whiffiagonis* and *L. boscii)* are assessed in ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). The model used in the assessment is Extended Survivors Analysis (XSA) (Shepherd, 1992), software VPA95 Lowestoft suite.

The XSA is a deterministic model. In recent years, the working group considers that it would be much more appropriate to use a model that incorporates uncertainty, especially since discards were included in the assessment.

During WGBIE 2020, a preliminary assessment with a4a statistical catch at age model was presented for megrim in 78abd. Based on that working document, this model was also chosen in a working group agreement to be tested in southern stocks.

2 Material and methods

The stock assessment model is a4a (assessment for all). It is a non-linear catch-at-age model implemented in R and FLR, and using ADMB. The model structure is defined by submodels, which are the different parts that require structural assumptions. There are 5 submodels in operation: a model for F-at-age, a model for the initial age structure, a model for recruitment, a (list) of model(s) for abundance indices catchability-at-age, and a list of models for the observation variance of catch-at-age and abundance indices (http://www.flr-project.org/doc/Statistical_catch_at_age_models_in_FLa4a.html).

A FLStock object is needed and it was adapted from XSA input data. This object includes catches, landings, discards, weights at age, natural mortality, maturity, harvest before spawning and mortality before spawning.

```
stock <- FLStock(catch.n =catches.n, landings.n= landings.n, discards.n=discards.n,
catch.wt=catches.wt,landings.wt=landings.wt, discards.wt=discards.wt, stock.wt=stock.wt,
catch= catches,landings=landings, discards=discards,
m=m, mat=mat,
harvest.spwn=harvest.spwn,m.spwn=m.spwn)
```

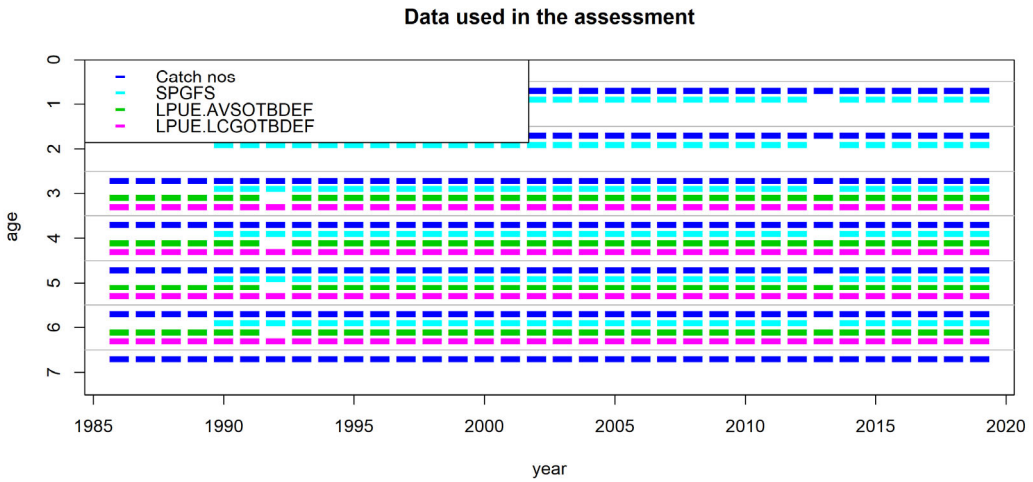
Also, for tuning indices, a FLIndices object was created for the three tuning fleets:

```
tun <- FLIndices(Tun1,Tun2,Tun3)
```

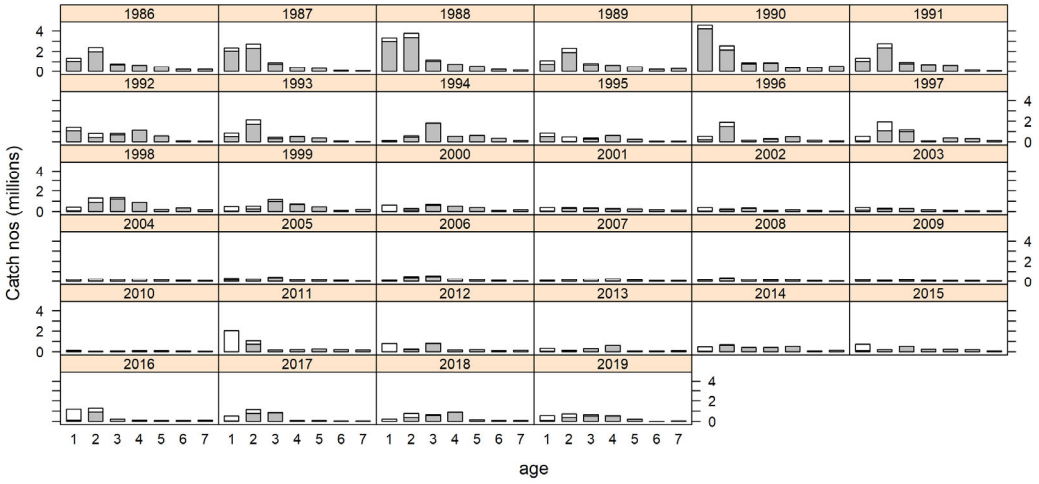
2.1. Input data and exploration: Megrim (*L. whiffiagonis*)

Input data, those defined in FLStock and FLIndices, were included in files inputmeg8c9a.RData and meg8c9aIndices.RData.

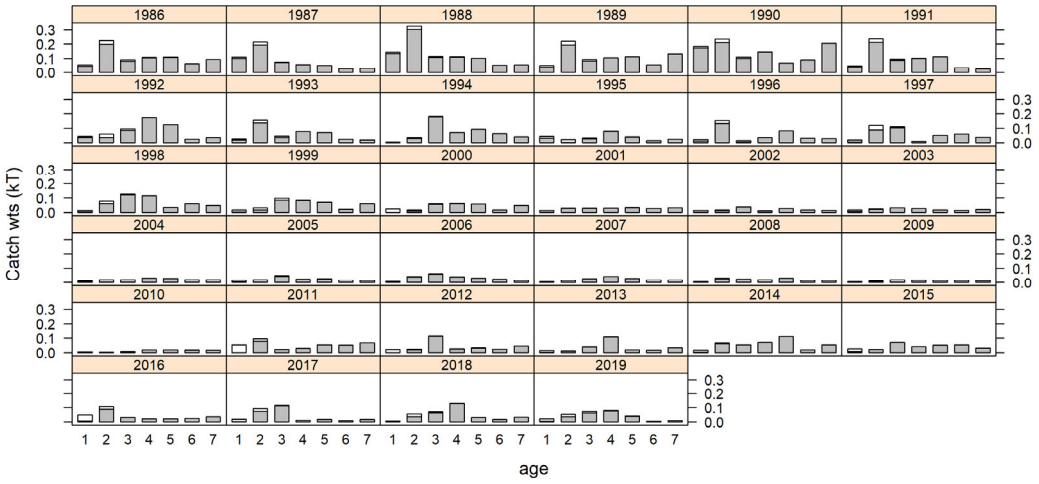
Tuning data for this stock are one Spanish groundfish survey (SpGFS-WIBTS-Q4) available since 1990 and two LPUE for the Spanish bottom trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF) and in Avilés port (SP-AVSOTBDEF) fishing in Division 8c since 1986. Data exploration can be seen in next outputs.



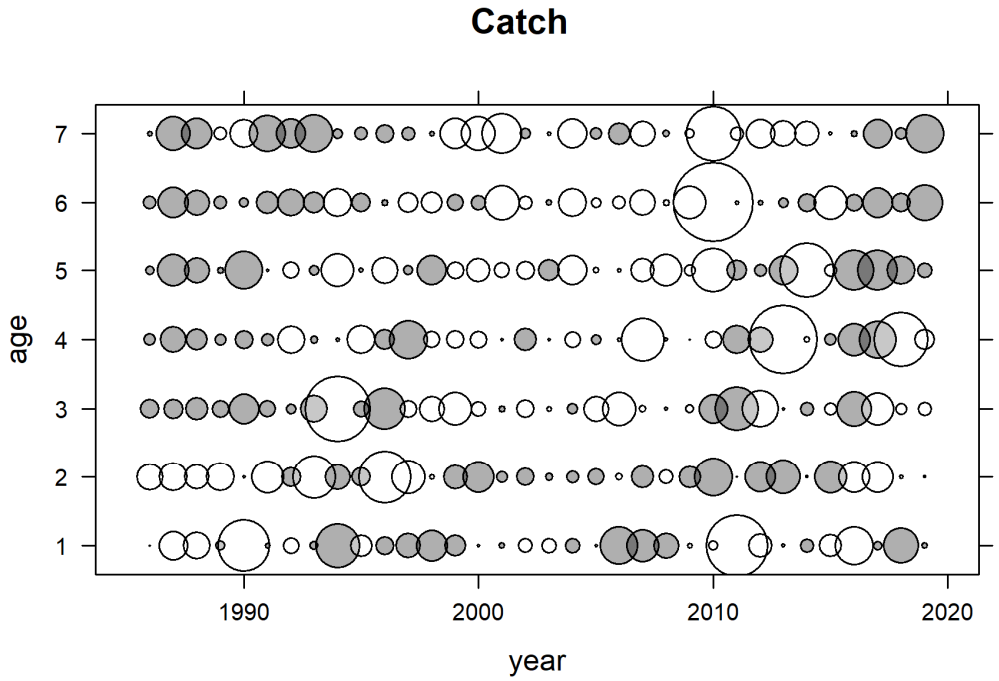
a. Input data used in the assessment. Catch (landings from Spain and Portugal, discards from Spain) and the three tuning fleets.



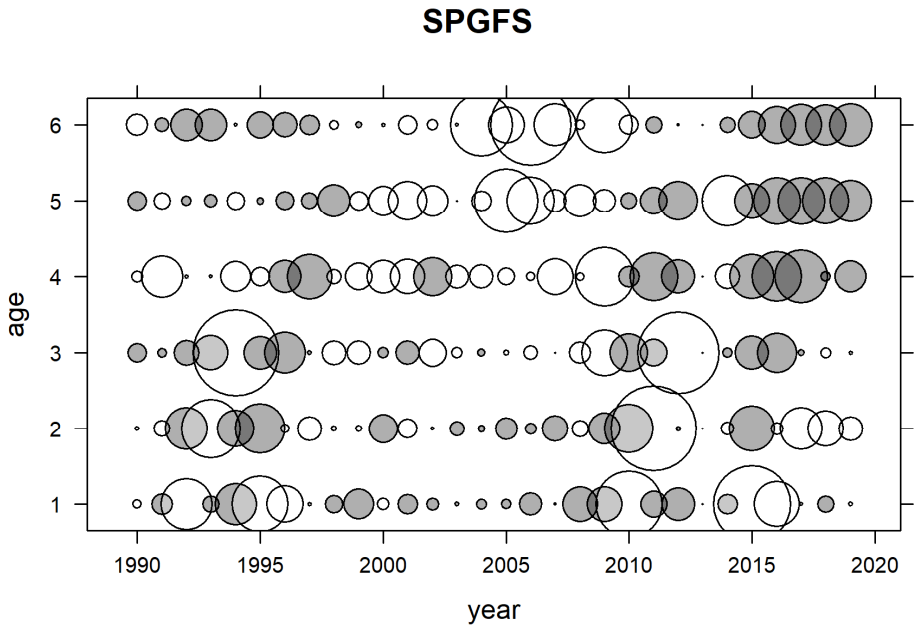
b. Catch numbers at age: landings are in grey, discards in white.



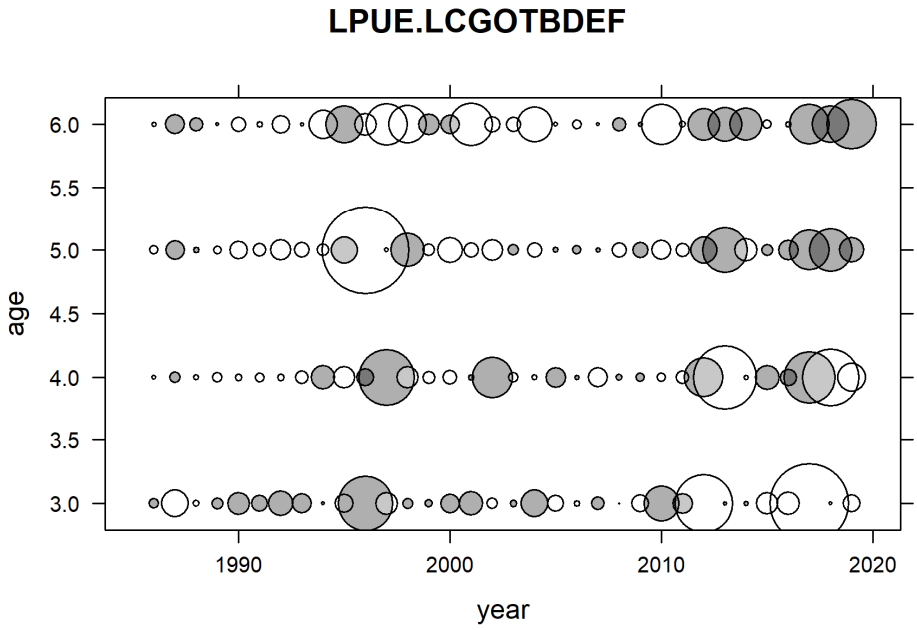
c. Catch weight at age: landings are in grey, discards in white.



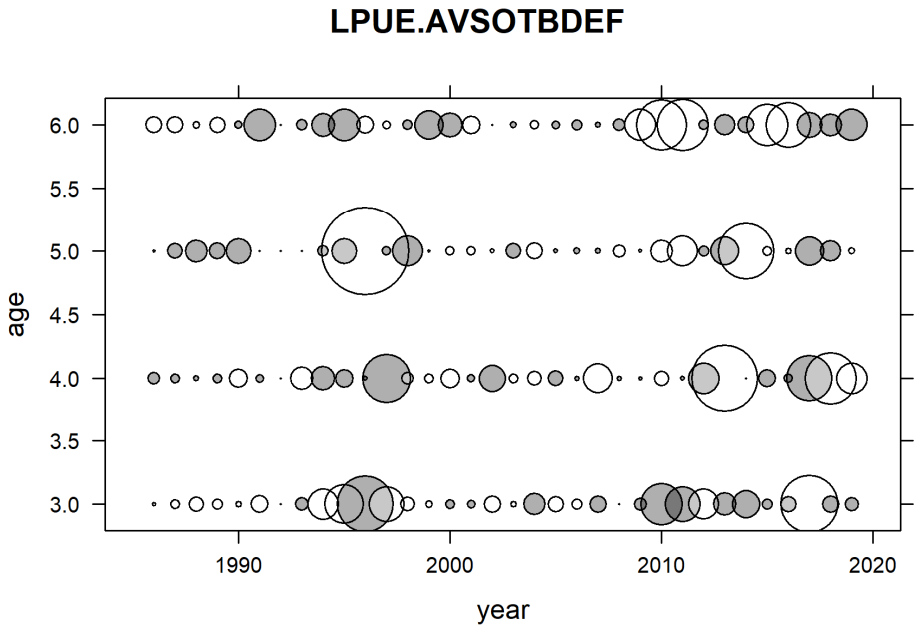
d. Catch by age data bubble plots, grey is below average, white is above average



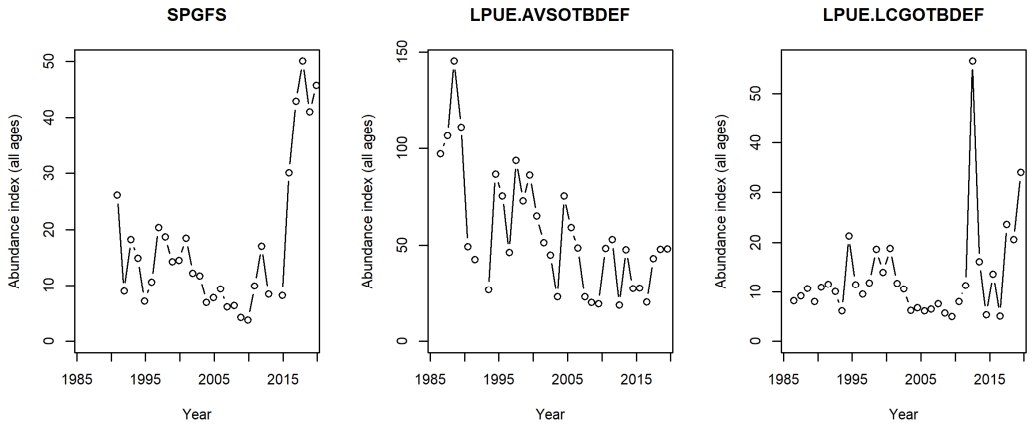
e. SpGFS-WIBTS-Q4 by age data bubble plots, grey is below average, white is above average



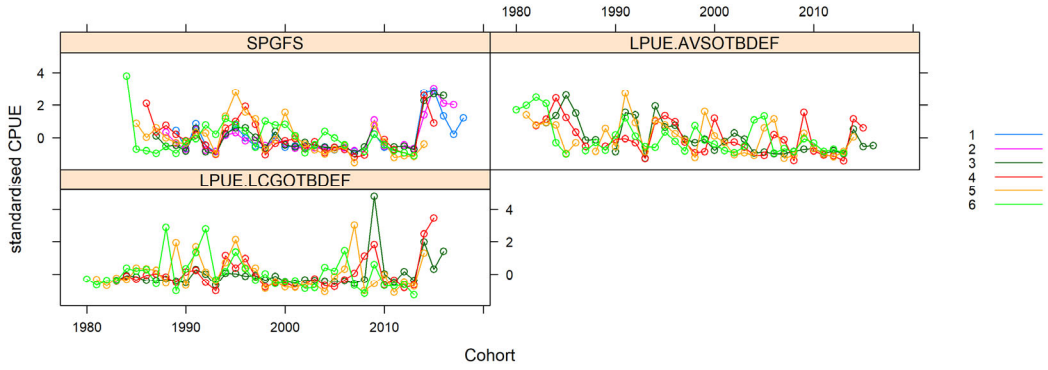
f. Commercial Coruña trawl by age data bubble plots, grey is below average, white is above average



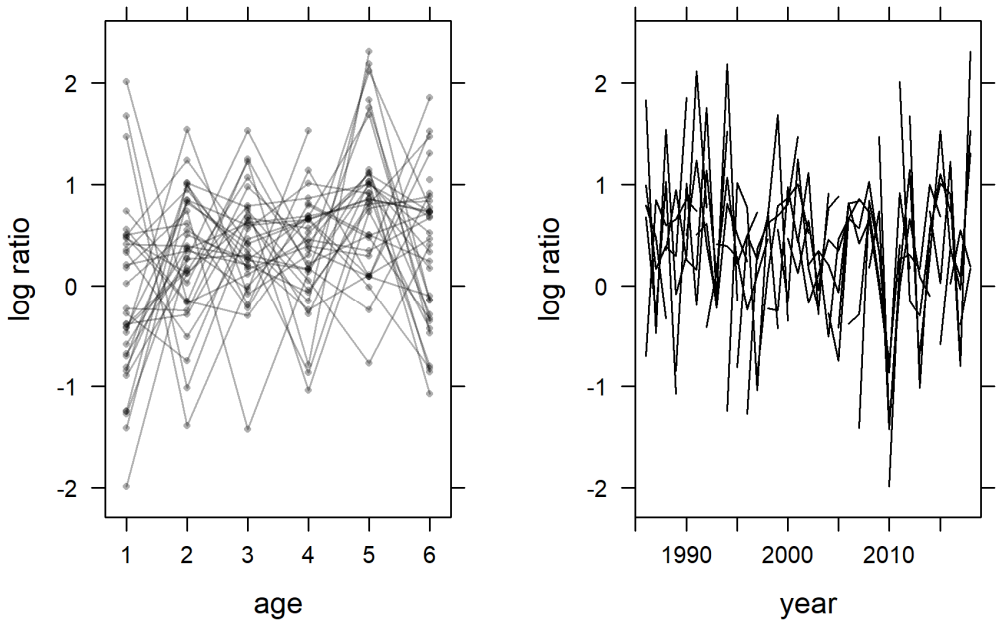
g. Commercial Avilés trawl by age data bubble plots, grey is below average, white is above average



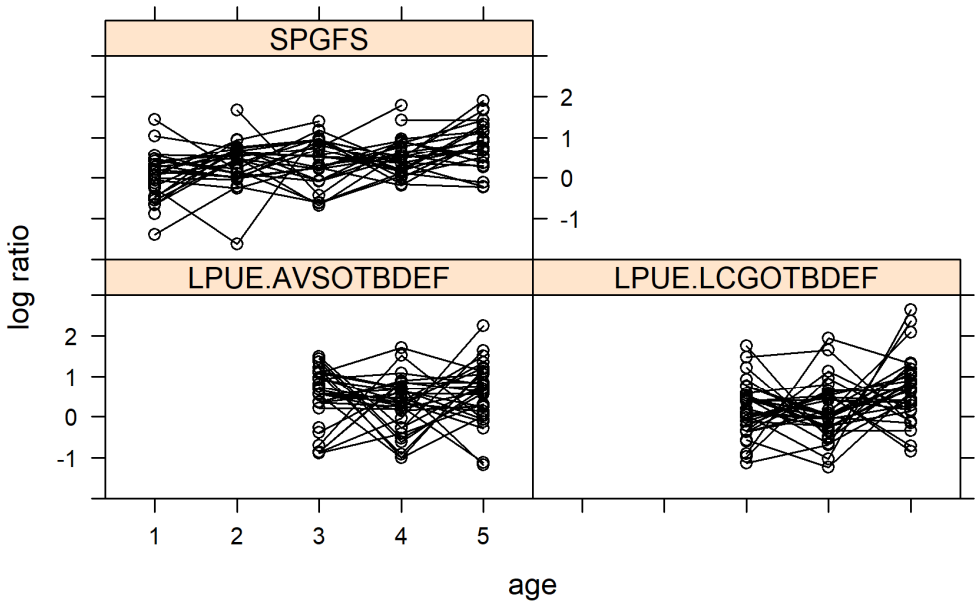
h. Abundance indices for all ages.



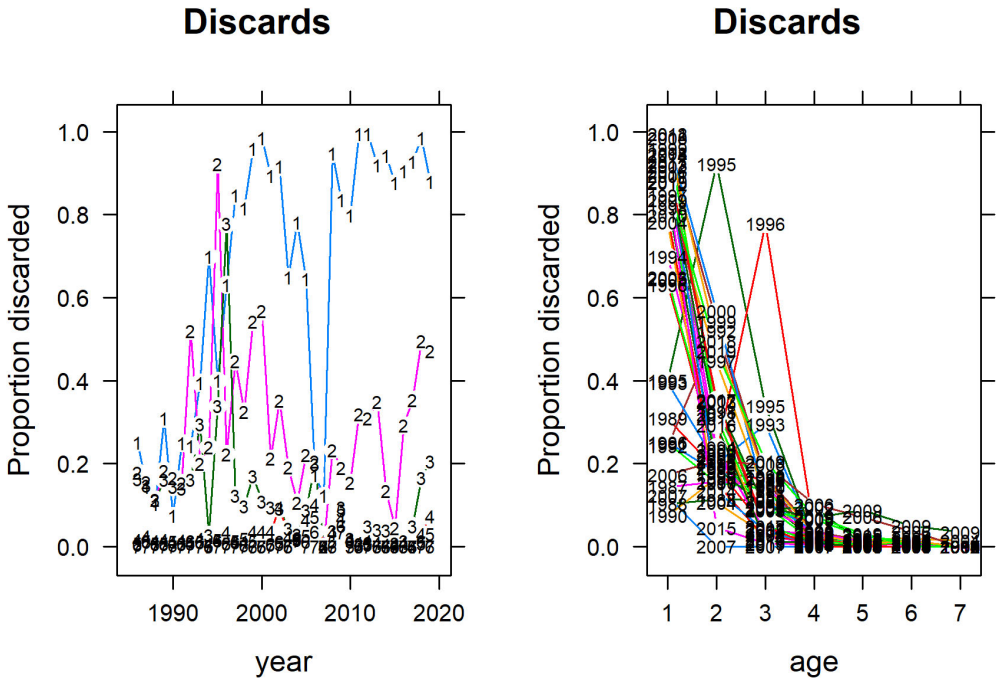
i. Standardised CPUE and LPUE by cohort of the tuning fleets.



j. Log ratio of the catch data by a age and by year.



k. Log-ratios of tuning fleet data

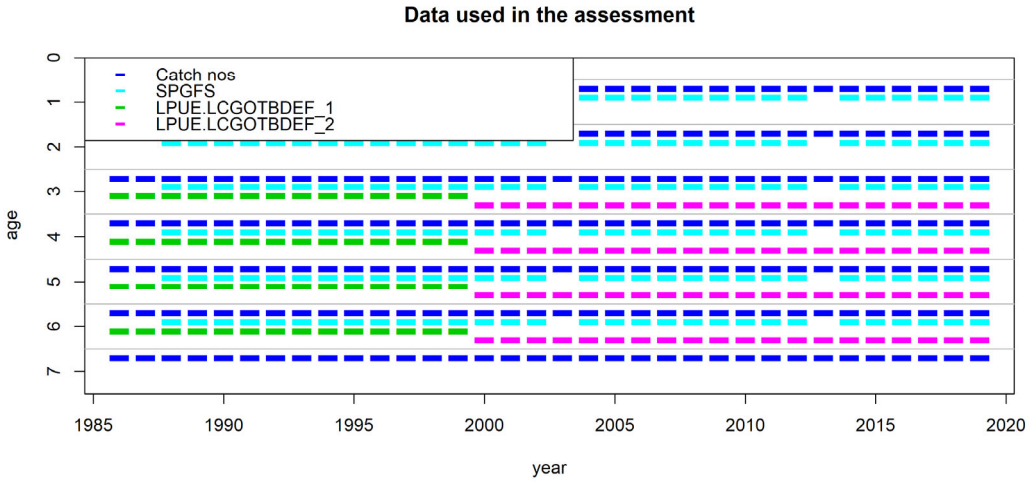


l. Proportion discarded by age and by year.

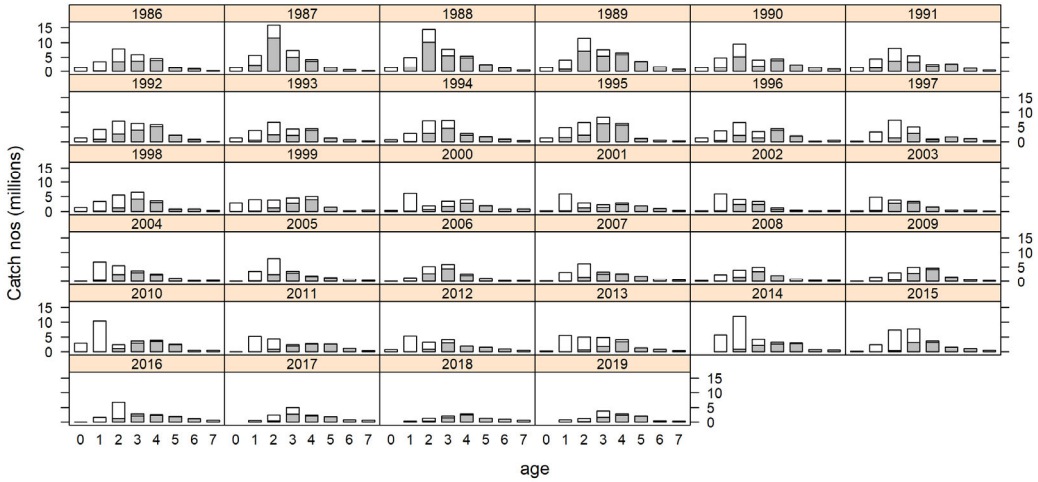
2.2. Input data and exploration: Four-spot megrim (*L. boscii*)

Input data, those defined in FLStock and FLIndices, were included in files inputldb8c9a.RData and ldb8c9aIndices.RData.

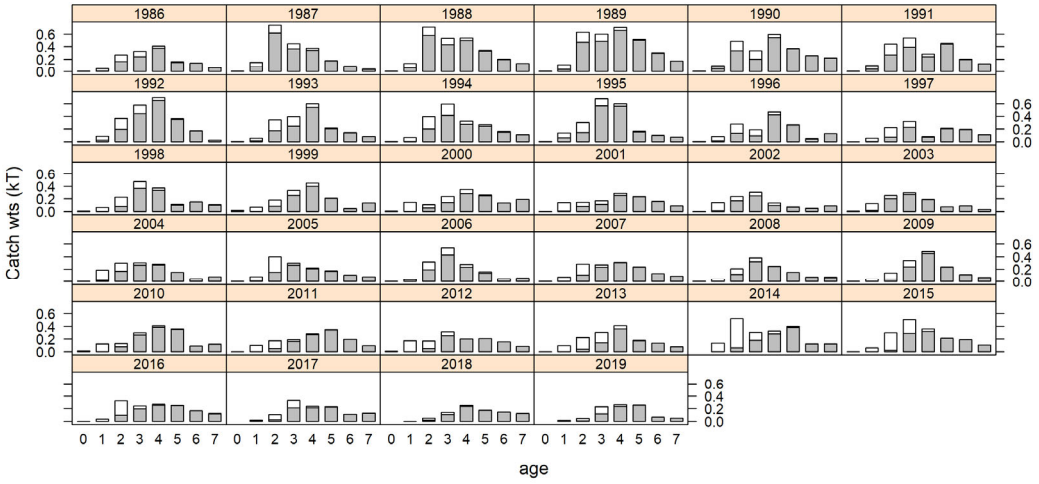
Tuning data for this stock are one Spanish groundfish survey (SpGFS-WIBTS-Q4) available since 1988 and two LPUEs for the Spanish bottom trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF-1 and SP-LCGOTBDEF-2) fishing in Division 8c and 9a which is really an index divided into two periods, from 1986 to 1990 and from 2000 onwards. Data exploration can be seen in next outputs.



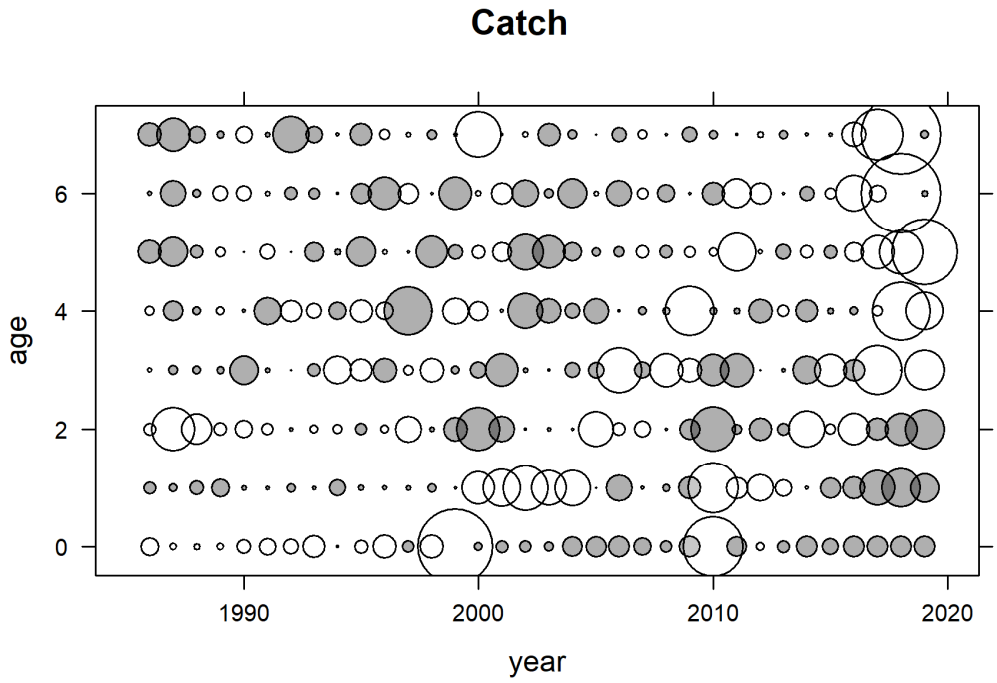
a. Input data used in the assessment. Catch (landings from Spain and Portugal, discards from Spain) and the three tuning fleets.



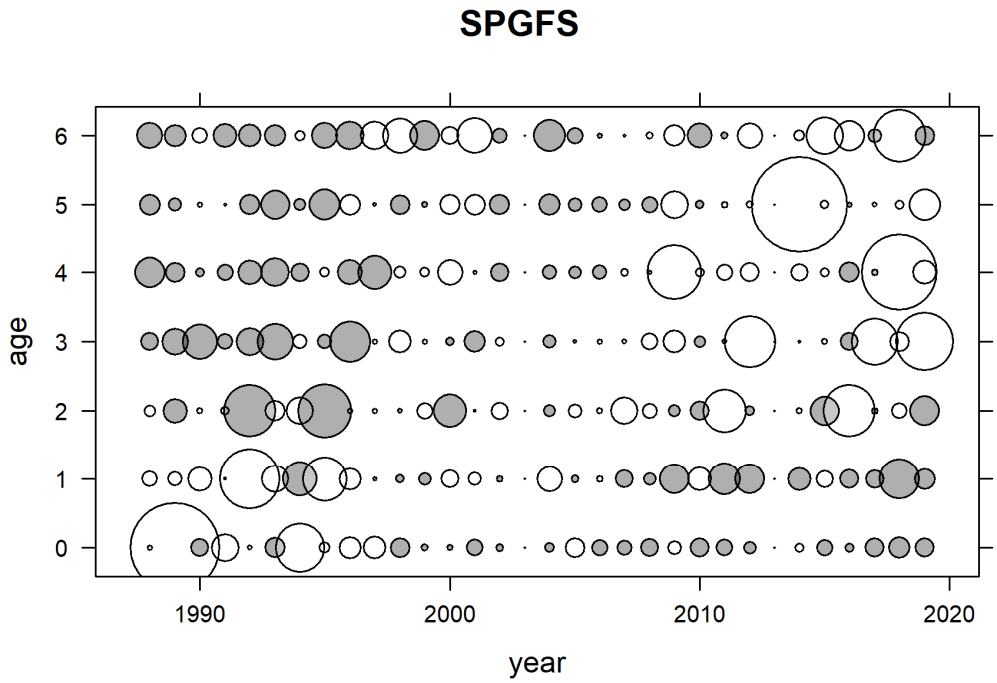
b. Catch numbers at age: landings are in grey, discards in white.



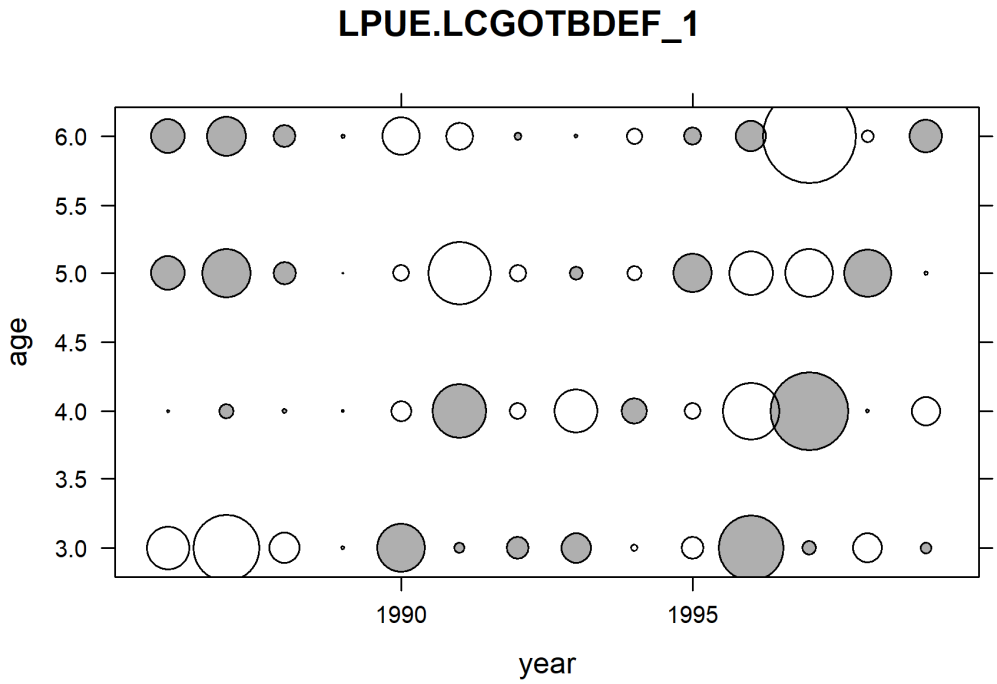
c. Catch weight at age: landings are in grey, discards in white.



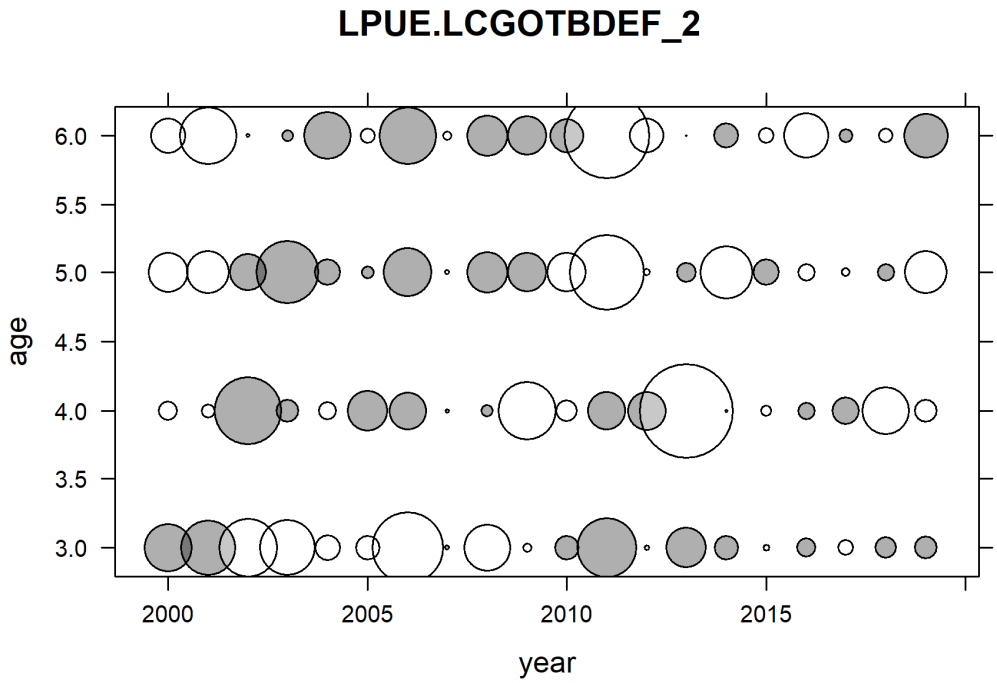
d. Catch by age data bubble plots, grey is below average, white is above average



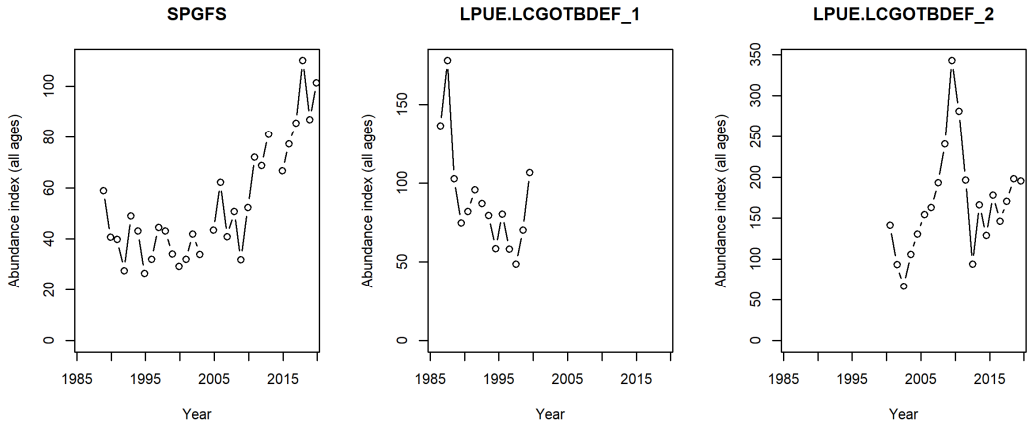
e. SpGFS-WIBTS-Q4 by age data bubble plots, grey is below average, white is above average



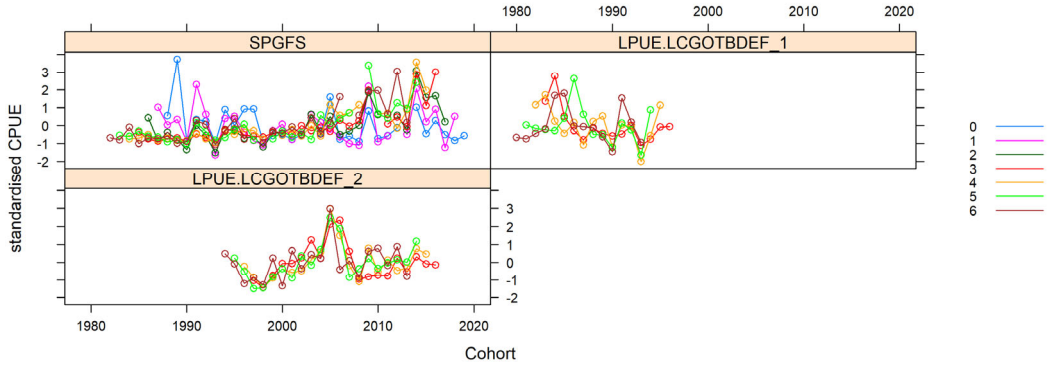
f. Commercial Coruña trawl LCGOTBDEF-1 by age data bubble plots, grey is below average, white is above average.



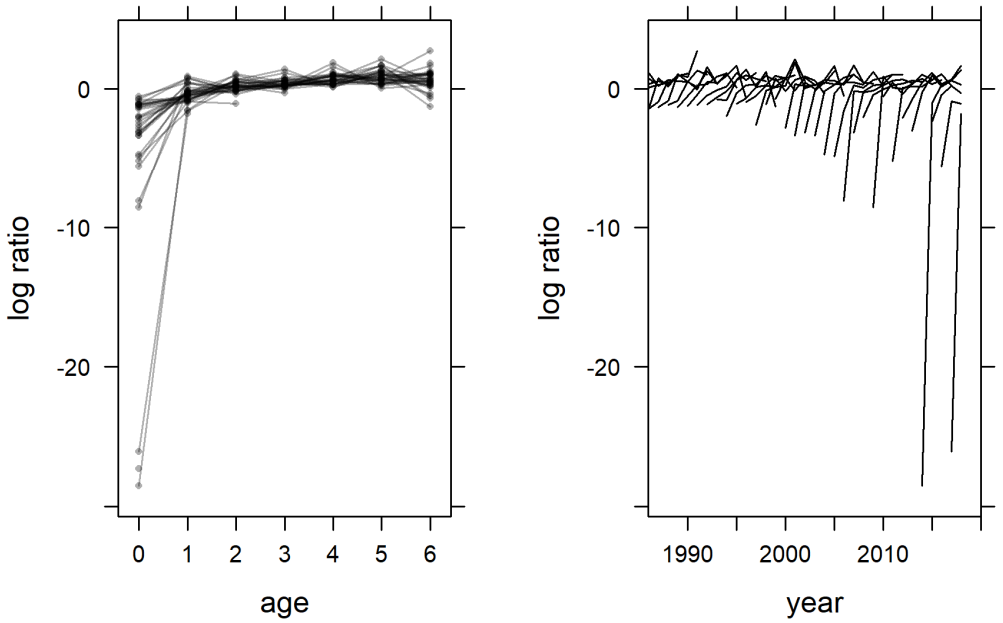
g. Commercial Coruña trawl LCGOTBDEF-2 by age data bubble plots, grey is below average, white is above average.



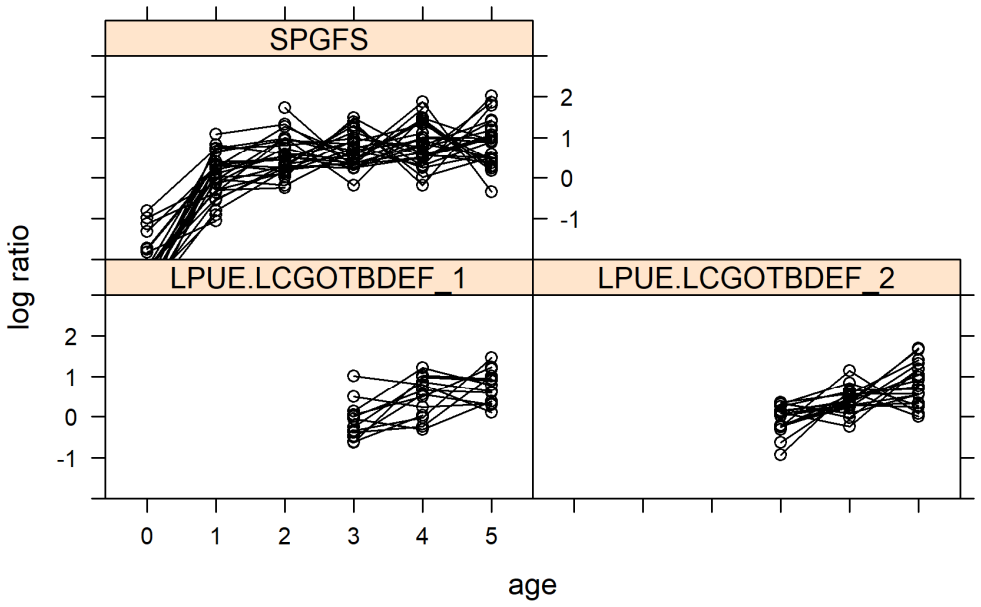
h. Abundance indices for all ages.



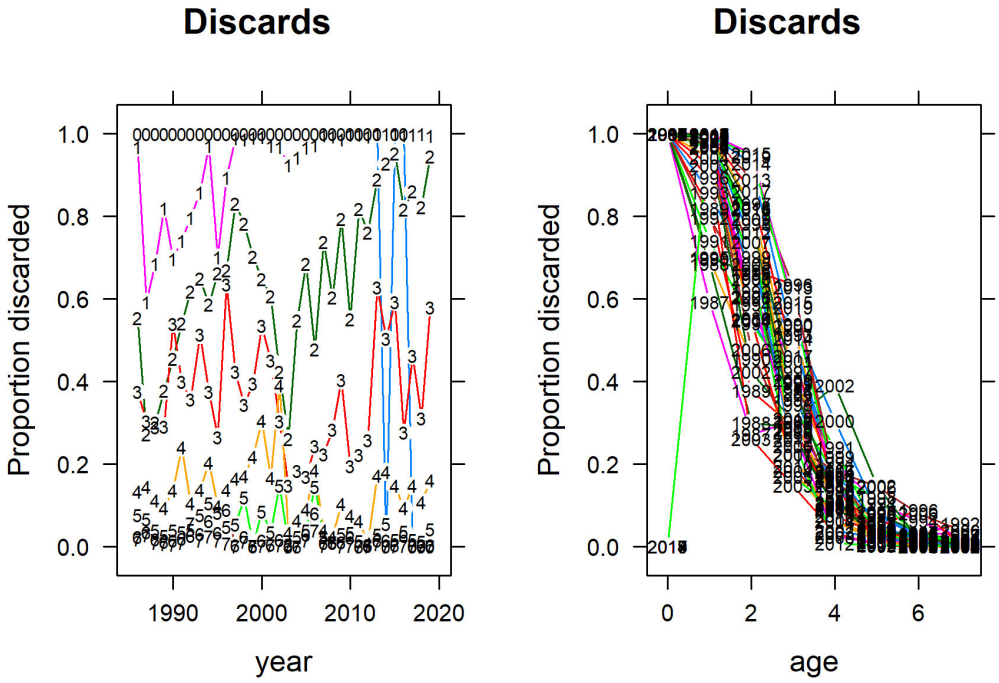
i. Standardised CPUE and LPUE by cohort of the tuning fleets.



j. Log ratio of the catch data by age and by year.



k. Log-ratios of tuning fleet data



l. Proportion discarded by age and by year.

3 Preliminary assessments (*L. whiffiagonis)*

Several fits have been tested in order to find an appropriate configuration for this stock. In this document the most relevant ones are presented.

3.1 Fit 1: Base case

The starting point, fit 1, was a default setting with the next submodels:

fmod (F at age): a formula object depicting the model for log fishing mortality at age.

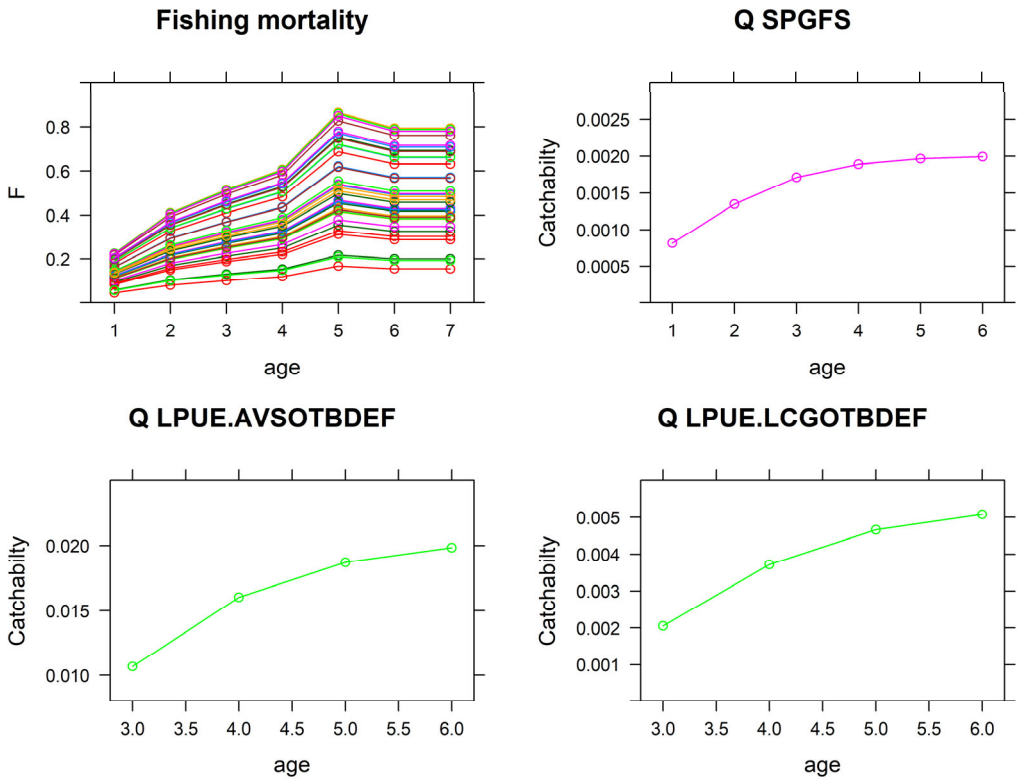
```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year)
```

srmod (model for recruitment): a formula object depicting the model for log recruitment.

```
srmod <- ~factor(year) #this stock-recruitment model (srmod) is 'free
```

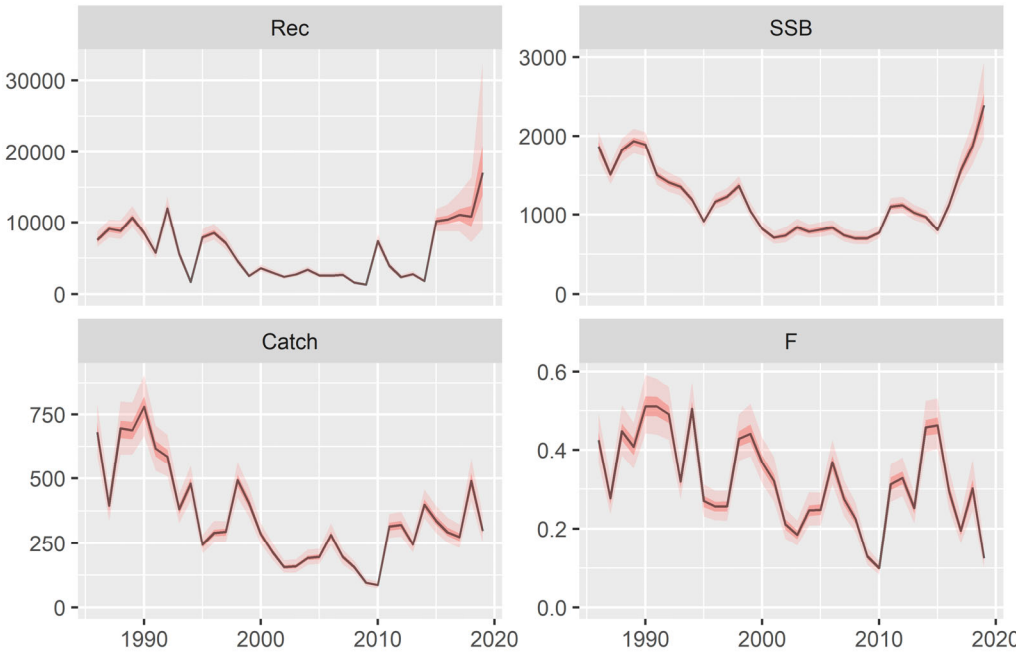
qmod (catchability at age): a list of formula objects depicting the models for log survey catchability at age.

```
qmod <- list(~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))))
# logistic function for all tuning fleets
```

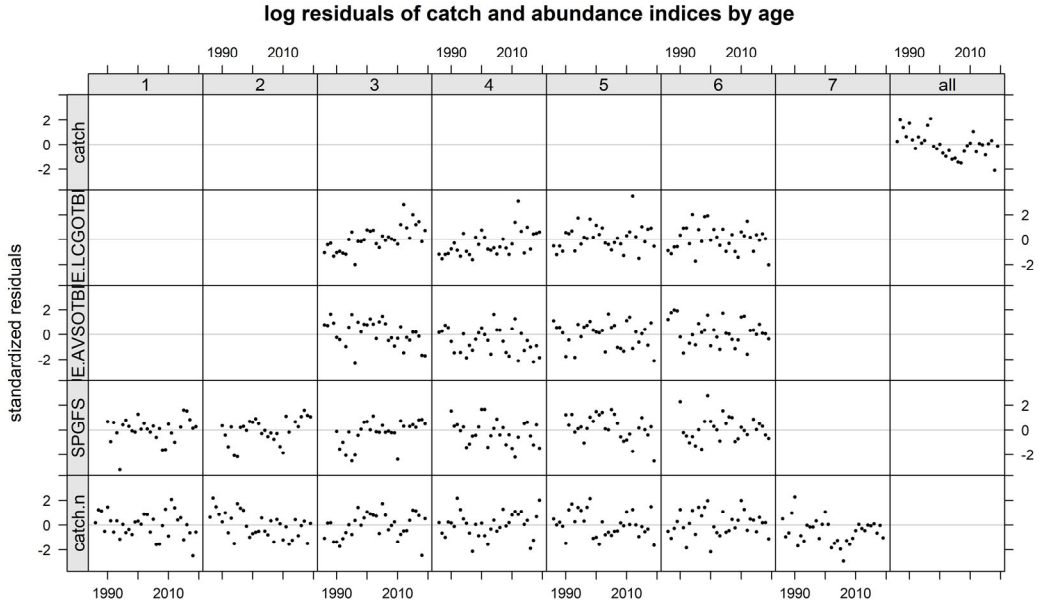


a. Fishing mortality and catchability of tuning fleets.

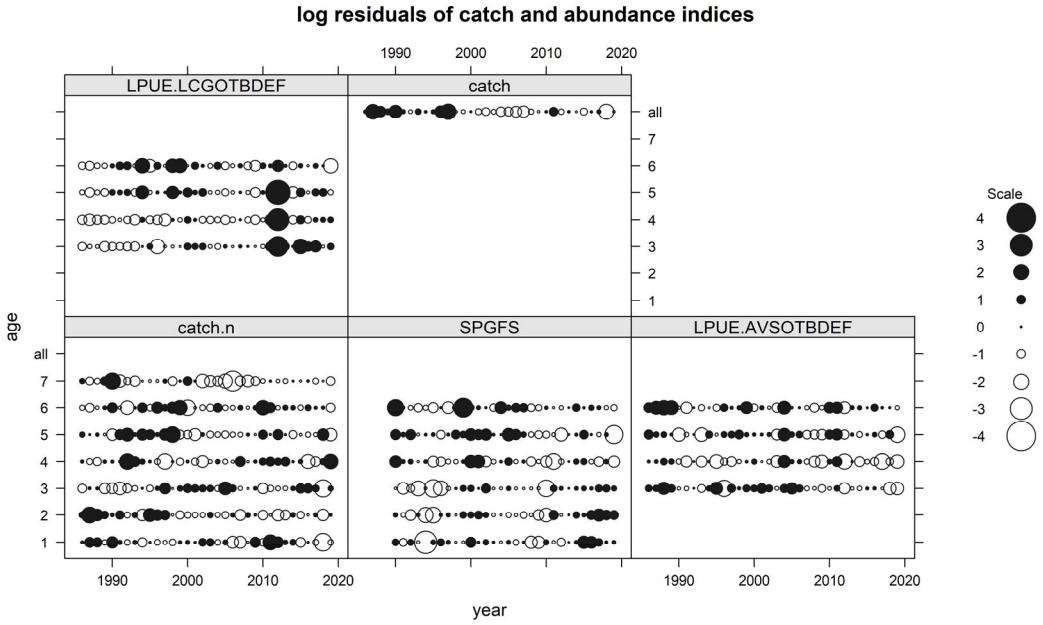
The results of this initial case were:



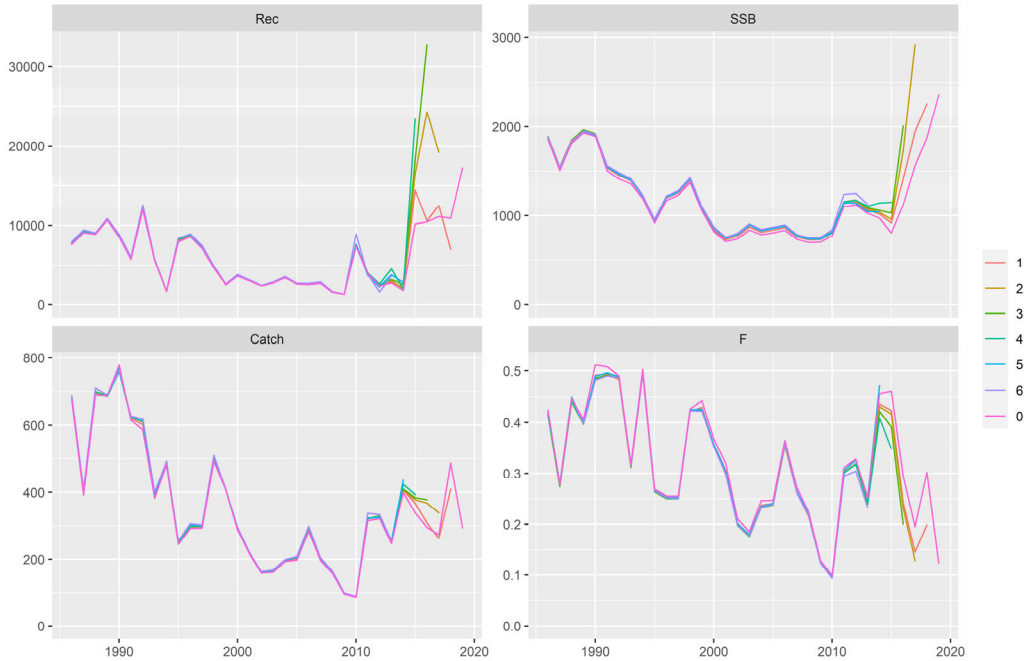
b. Outputs of the assessment; Recruitment, SSB and F.



c. Log residuals of catch and abundance indices by age.



d. Bubble plots of log residuals of catch and abundance indices by age.

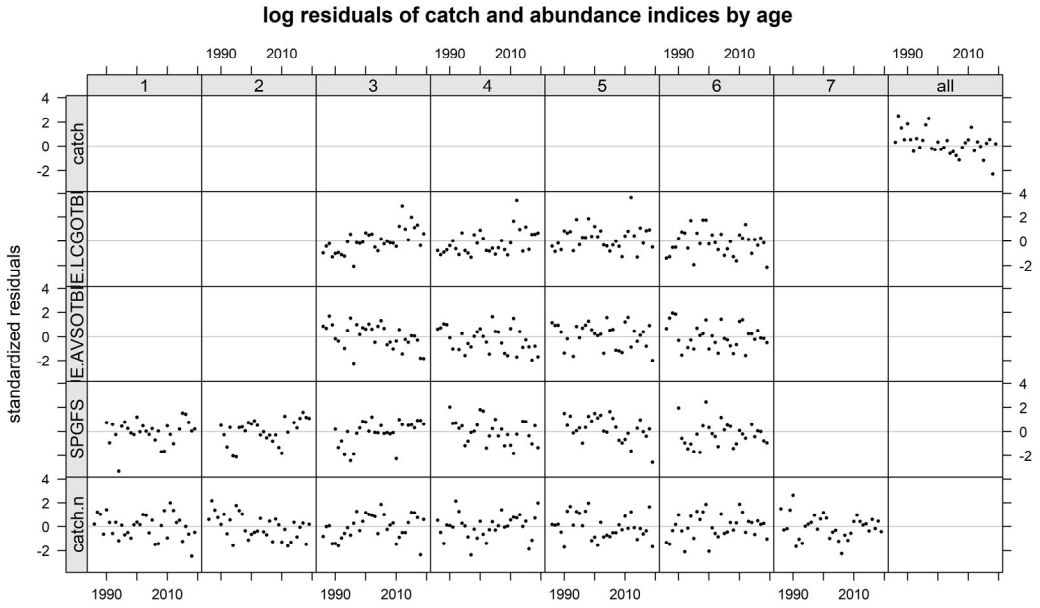


e. Retrospective pattern plots over the last 6 years

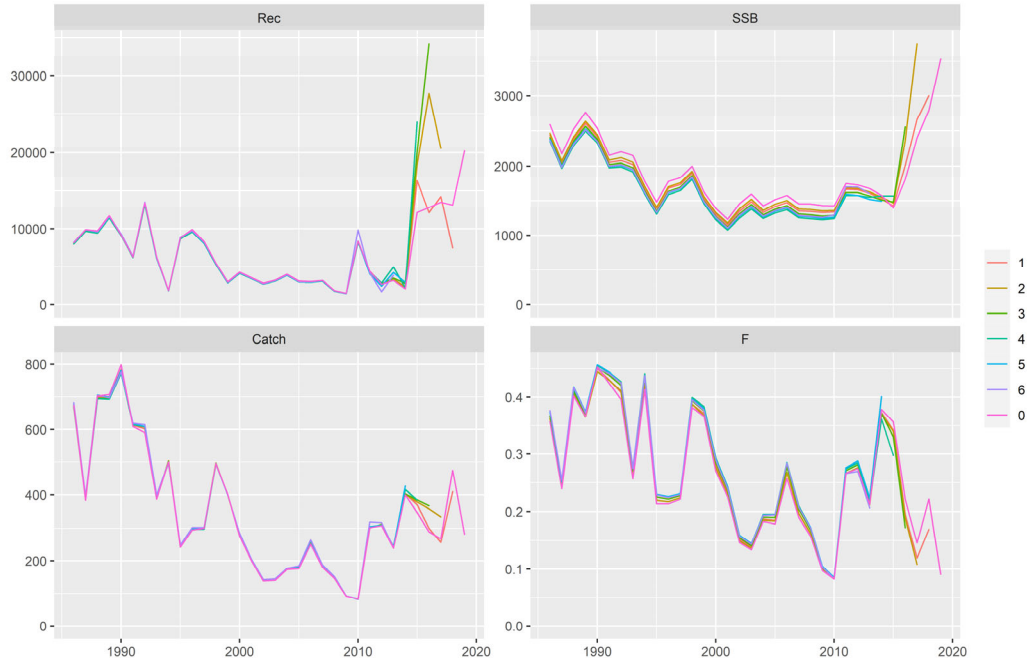
3.2 Fit 2: Adding a smooth term in the catchability model for the survey

Starting from the previous case, a smooth term is added to avoid the age effect in the survey index. The added term is the next one:

```
qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 3),
        ~I(1/(1 + exp(-age))),
        ~I(1/(1 + exp(-age))))
```



a. Log residuals of catch and abundance indices by age.

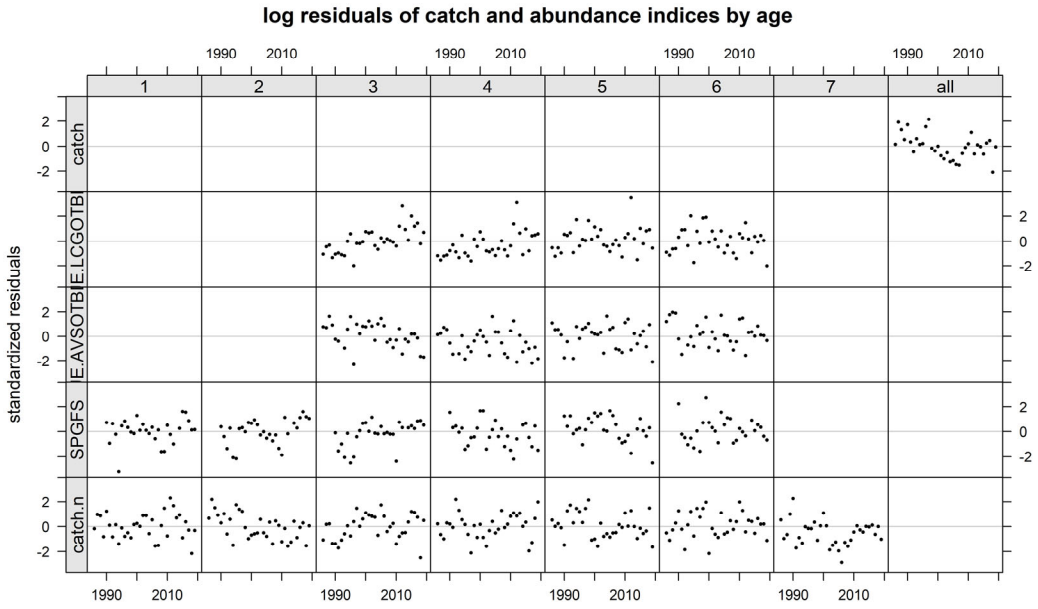


b. Retrospective pattern plots over the last 6 years

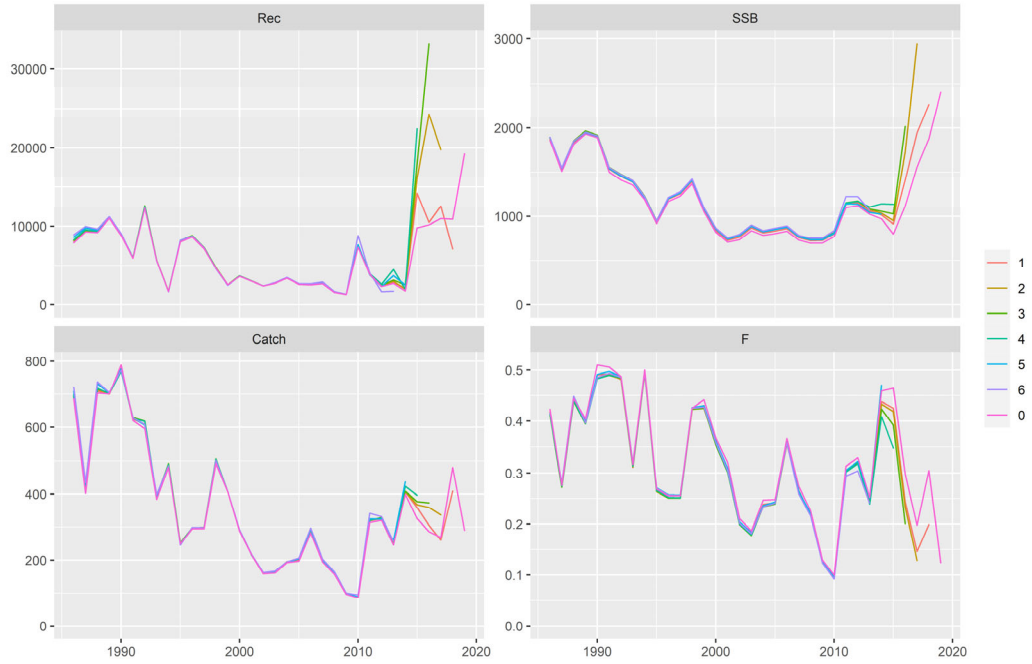
3.3 Fit 10: Adding a smooth term to age 1 in fishing mortality model.

This case was done to reduce the variability that is usually associated to the first age. To do this we added a smooth term to the fishing mortality model of the base case.

fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 1))



a. Log residuals of catch and abundance indices by age.

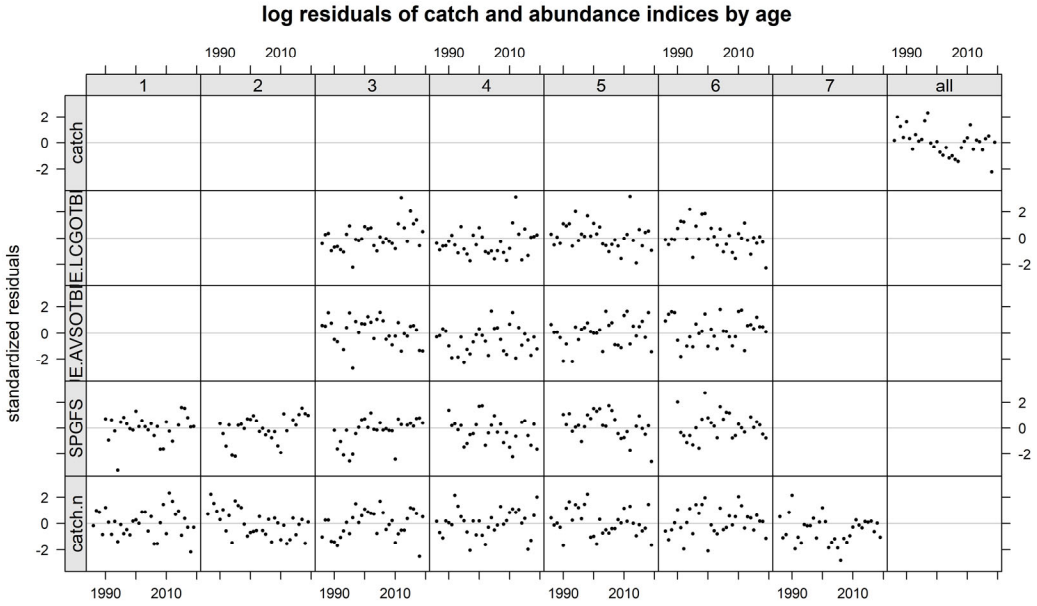


b. Retrospective pattern plots over the last 6 years

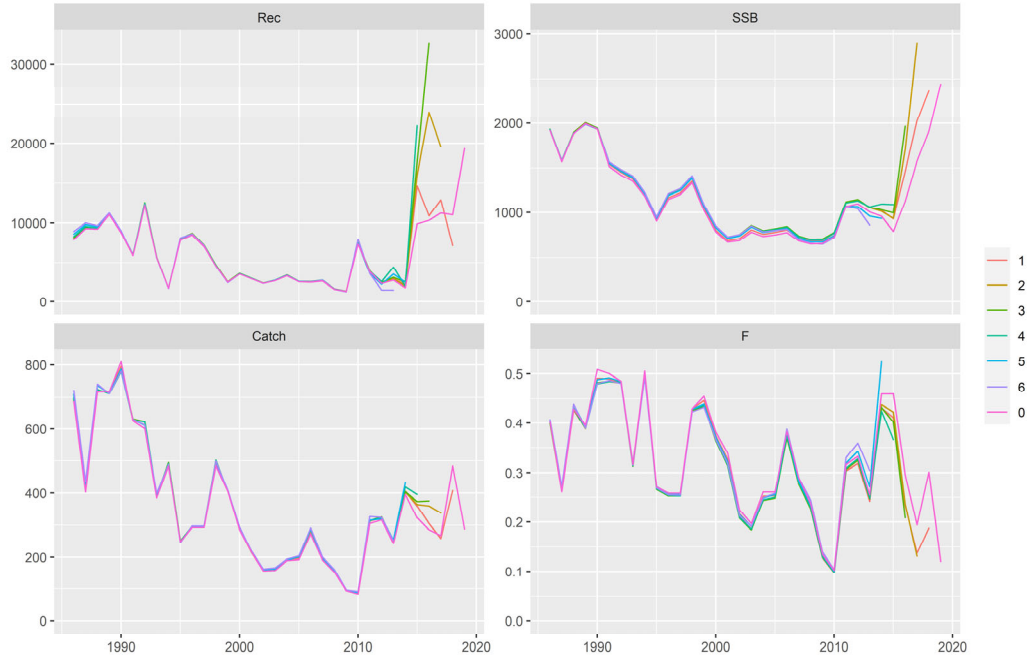
3.4 Fit 13: Adding a smooth term to age 1 in fishing mortality model and smooth terms in the catchability model for the commercial fleets.

In the last case presented, to the options of the previous one smooth terms were added to the catchability model of the commercial fleet indices to smooth the variability by years.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 1))
qmod <- list(~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age)))+s(year, k = 3),
             ~I(1/(1 + exp(-age)))+s(year, k = 3))
```

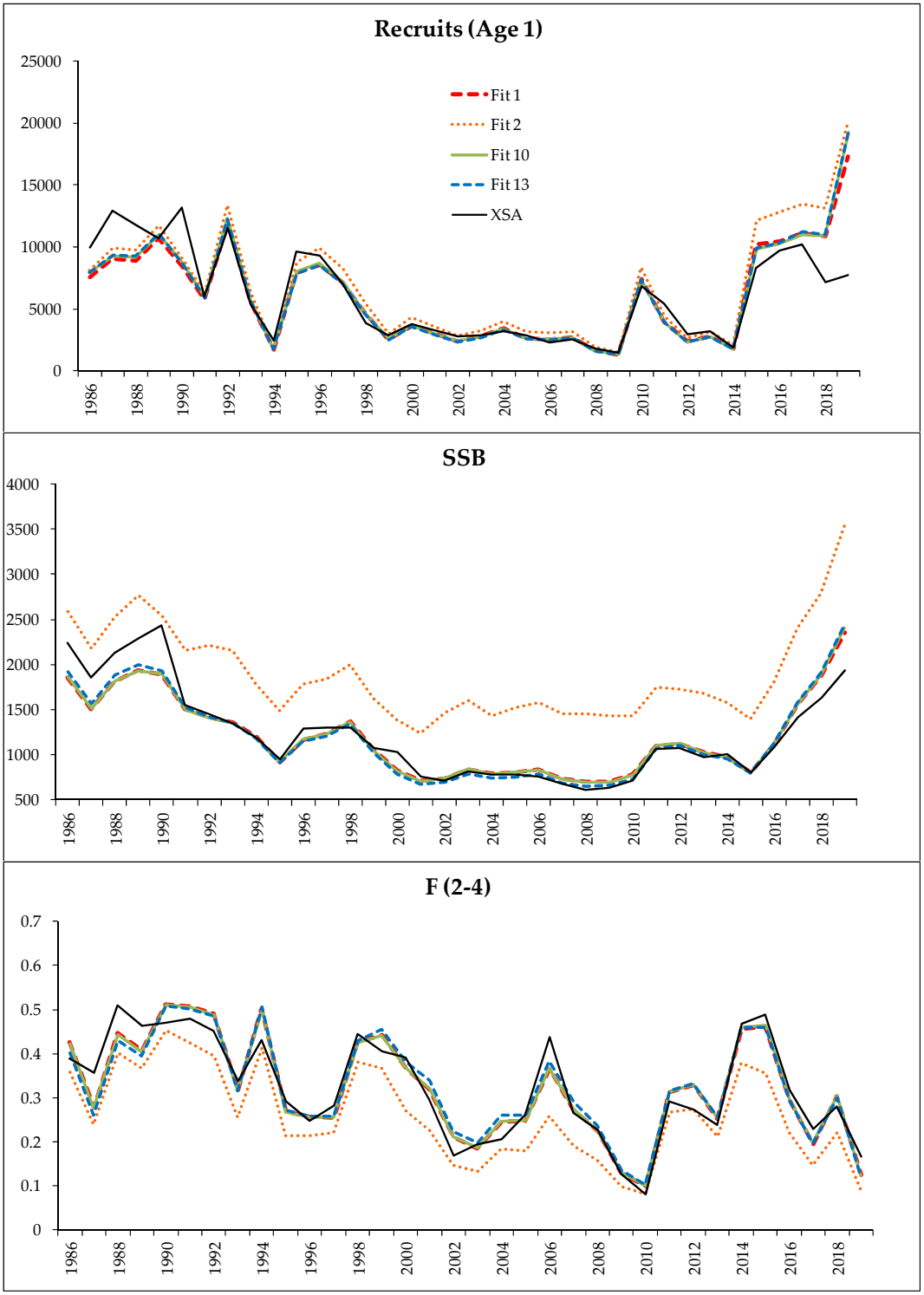


c. Log residuals of catch and abundance indices by age.



d. Retrospective pattern plots over the last 6 years

4 Comparison with the current assessment (XSA, 2020WGBIE).



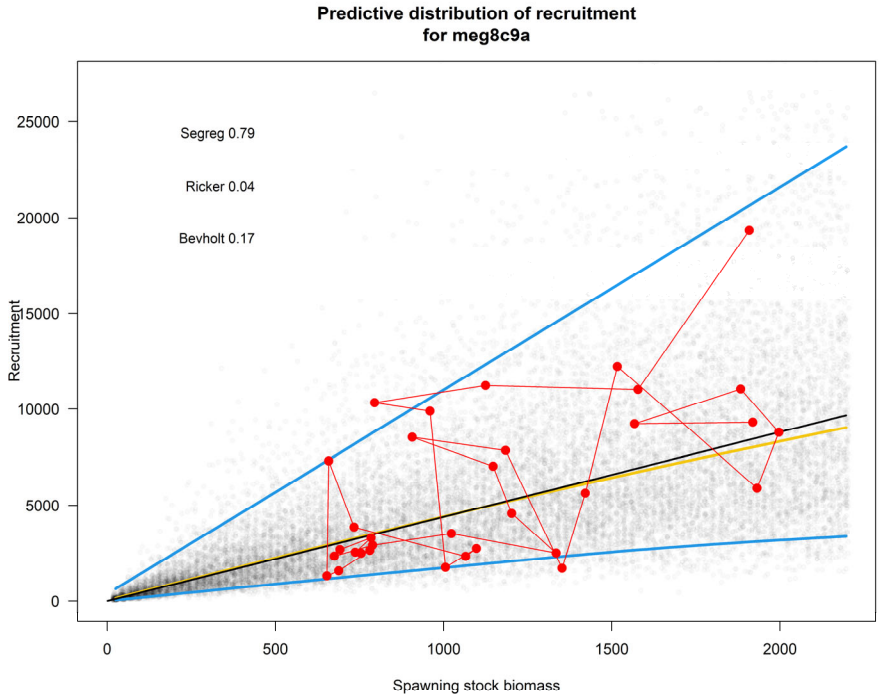
a. XSA Stock status estimates versus a4a estimates in the studied fits for *L. whiffiagonis*.

b. Table with AIC, BIC and Mohn's Rho values of the different fits.

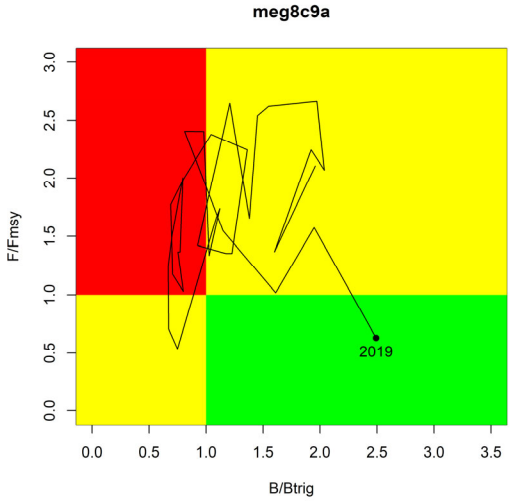
	AIC	BIC	Mohn's Rho (Retro_F)	Mohn's Rho (Retro_SSB)	Mohn's Rho (Retro_R)
XSA WG2020			-0.34	0.35	0.17
Fit 1	1158.2	1556.2	-0.086	0.252	0.756
Fit 2	1143.4	1554.9	-0.058	0.152	0.623
Fit 10	1160.8	1557.9	-0.083	0.241	0.619
Fit 13	1140.6	1565.6	0.042	0.134	0.533

5 Preliminary Biological Reference Points, forecast and Catch option table

With the availability of codes to estimate the biological reference points and the catch projections, fit 13 was selected to obtain preliminary values. This selection was based on the best AIC and Mohn's Rho values.



a. Stock-Recruitment plot.



Btrigger	907.2
Fmsy	0.164
Blim	652.9
Bpa	907.2
Flim	0.415
Fpa	0.299
lFmsy	0.116
uFmsy	0.269
F05	1.072

b. Kobe plot and BRP values.

c. Catch options table:

basis	catch	wanted	unwanted	F	Fwanted	Funwanted	SSB	ssbchange	advicechange
MSY approach: F[MSY]	630	609	21	0.164	0.187	0.044	3185	-13	20
F=MAP F[MSY lower]	459	444	15	0.116	0.132	0.031	3388	-7.5	-12.4
F=MAP F[MSY upper]	970	937	33	0.269	0.307	0.073	2784	-24	85
MSY approach: F[MSY]	630	609	21	0.164	0.187	0.044	3185	-13	20
F[mp]	753	727	26	0.2	0.229	0.054	3040	-17	44
F=0	0	0	0	0	0	0	3933	7.4	-100
F[pa]	1059	1023	37	0.299	0.342	0.081	2680	-27	102
F[lim]	1373	1325	48	0.415	0.475	0.112	2312	-37	162
SSB (2022)=B[pa]	2600	2502	98	1.173	1.341	0.317	907	-75	400
SSB(2022)=B[lim]	2832	2723	108	1.448	1.655	0.391	653	-82	440
SSB(2022)=MSY B[trigger]	2600	2502	98	1.173	1.341	0.317	907	-75	400
F[2020]	477	461	16	0.121	0.138	0.033	3366	-8.1	-8.9
Roll-over TAC	524	506	18	0.133	0.153	0.036	3311	-9.6	0

6 Preliminary assessments (*L. boscii)*

For this stock several fits have been tested too and the most relevant are presented.

6.1 Fit 1: Base case

Fit 1, the base one, is the same that was shown for megrim:

fmod (F at age): a formula object depicting the model for log fishing mortality at age.

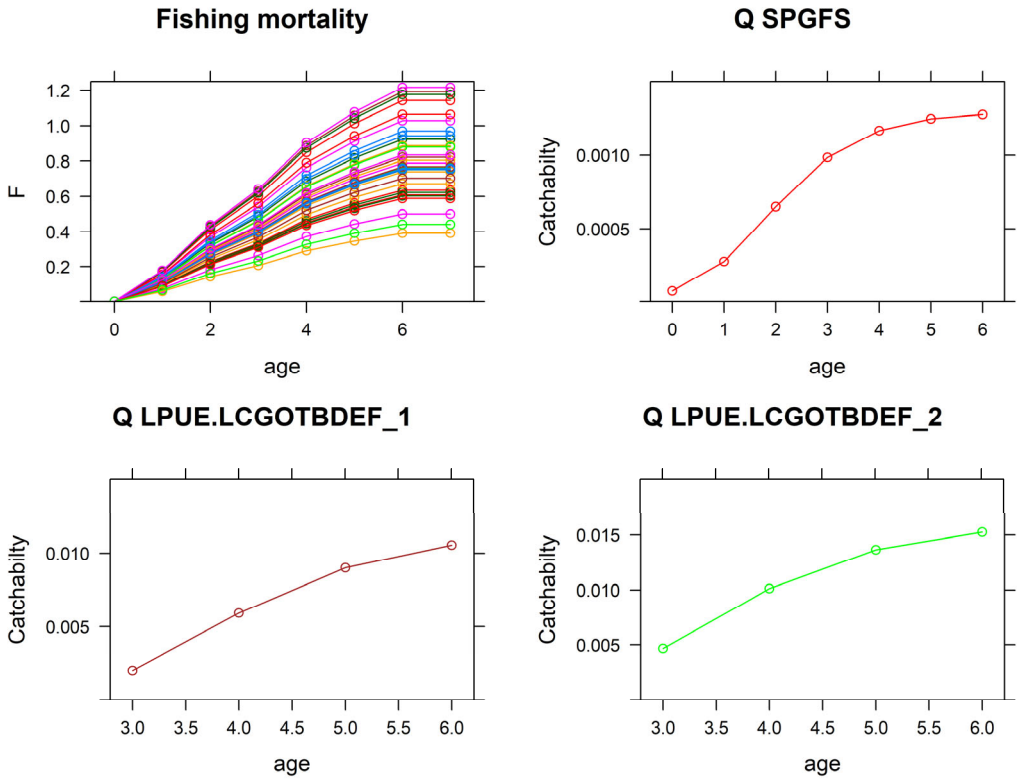
```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year)
```

srmod (model for recruitment): a formula object depicting the model for log recruitment.

```
srmod <- ~factor(year) #this stock-recruitment model (srmod) is 'free
```

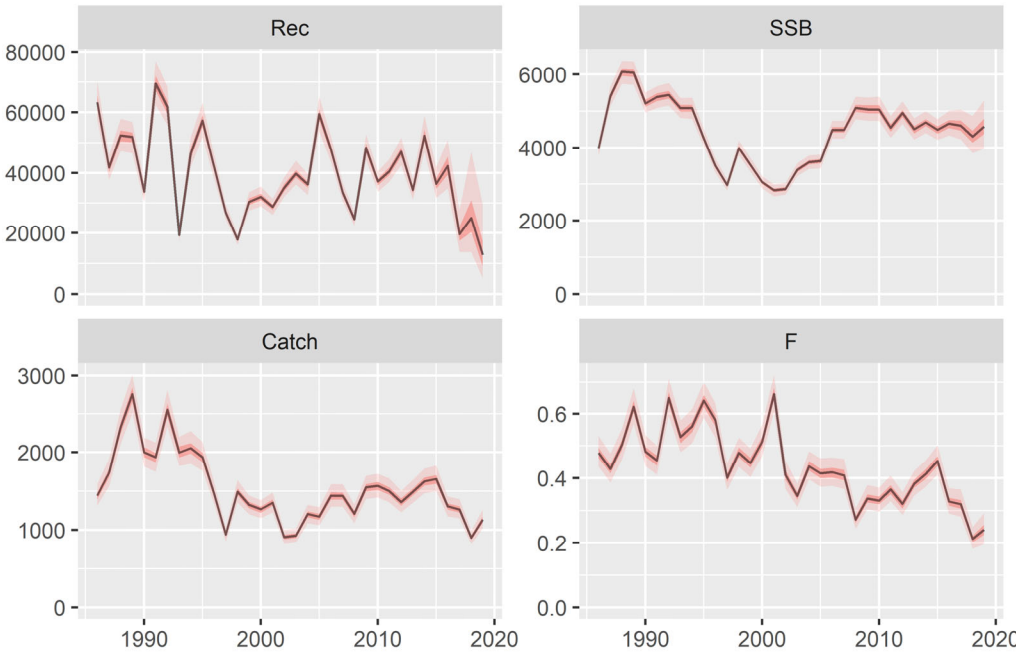
qmod (catchability at age): a list of formula objects depicting the models for log survey catchability at age.

```
qmod <- list(~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))))
# logistic function for all tuning fleets
```

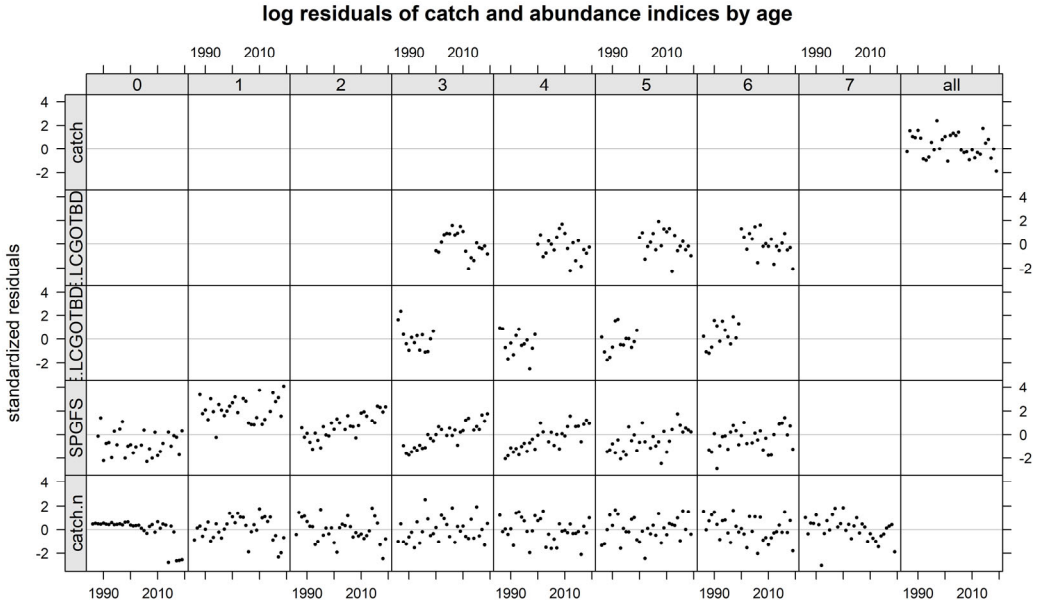


f. Fishing mortality and catchability of tuning fleets.

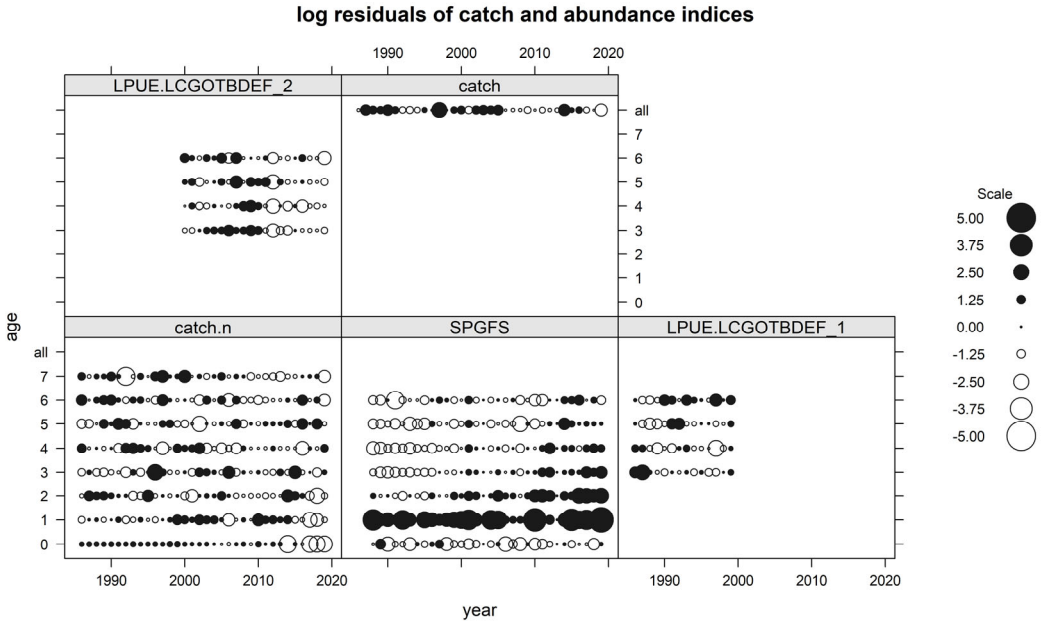
The results of this initial case were:



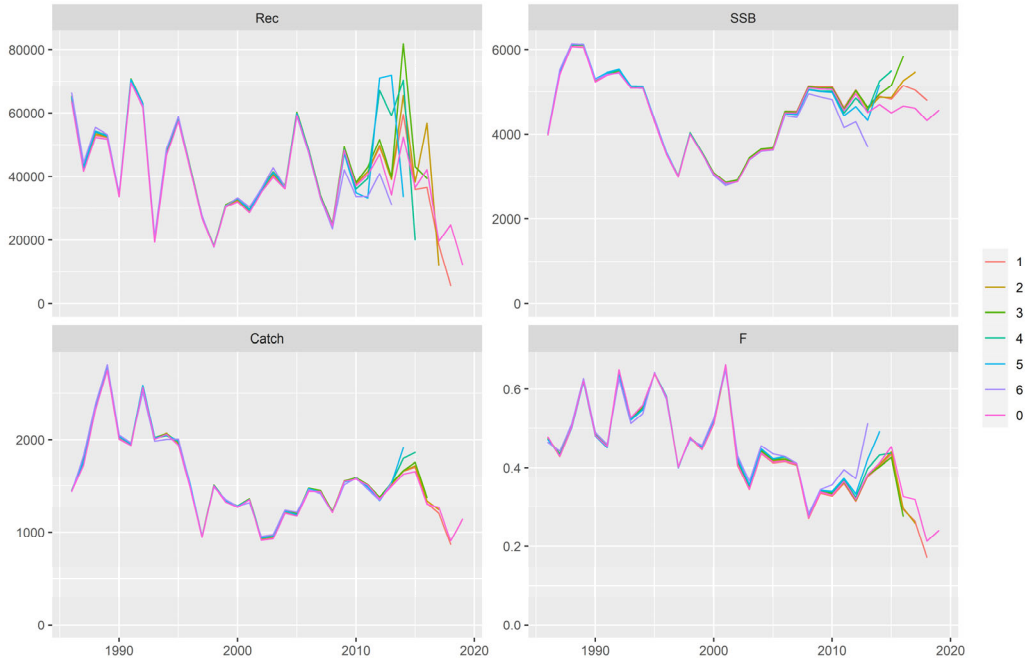
g. Outputs of the assessment; Recruitment, SSB and F.



h. Log residuals of catch and abundance indices by age.



i. Bubble plots of log residuals of catch and abundance indices by age.



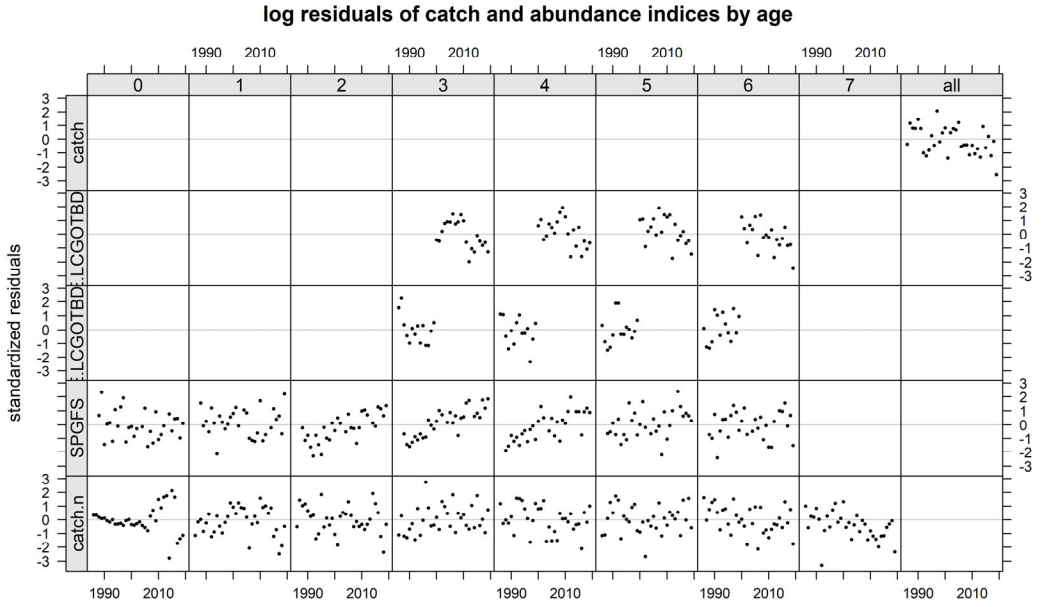
j. Retrospective pattern plots over the last 6 years

6.2 Fit 12: Adding a smooth term to age 0 in fishing mortality model and a smooth term in the catchability model for the survey.

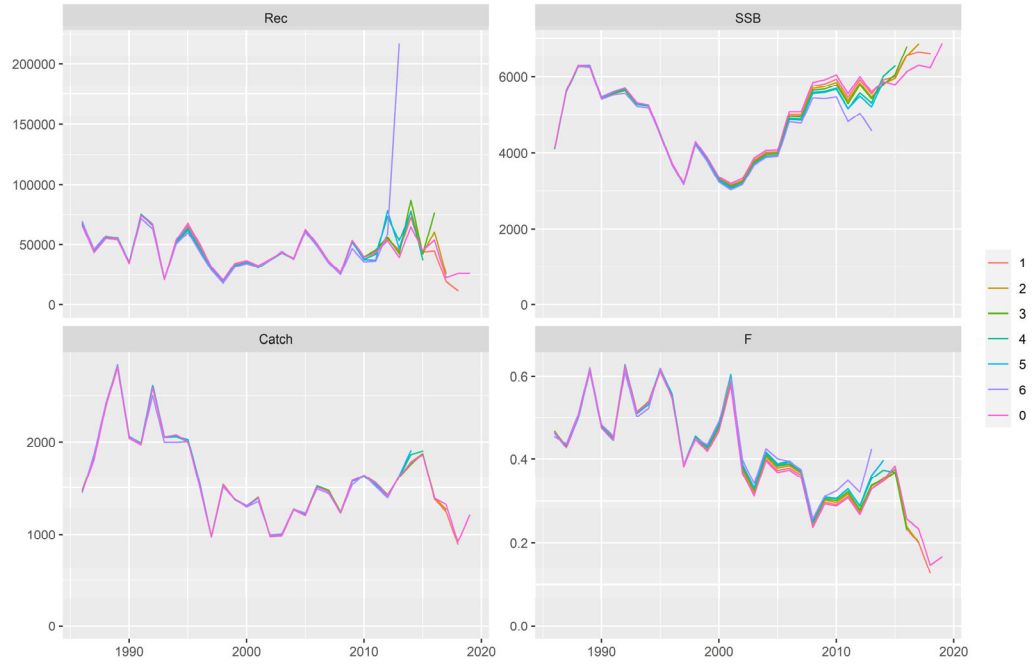
Residuals in fit 1 showed issues in age 0 in the catch and in age 1 in the survey. Smooth terms are added to try to improve the residuals. They are:

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 0))

qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
        ~I(1/(1 + exp(-age))),
        ~I(1/(1 + exp(-age))))
```



c. Log residuals of catch and abundance indices by age.

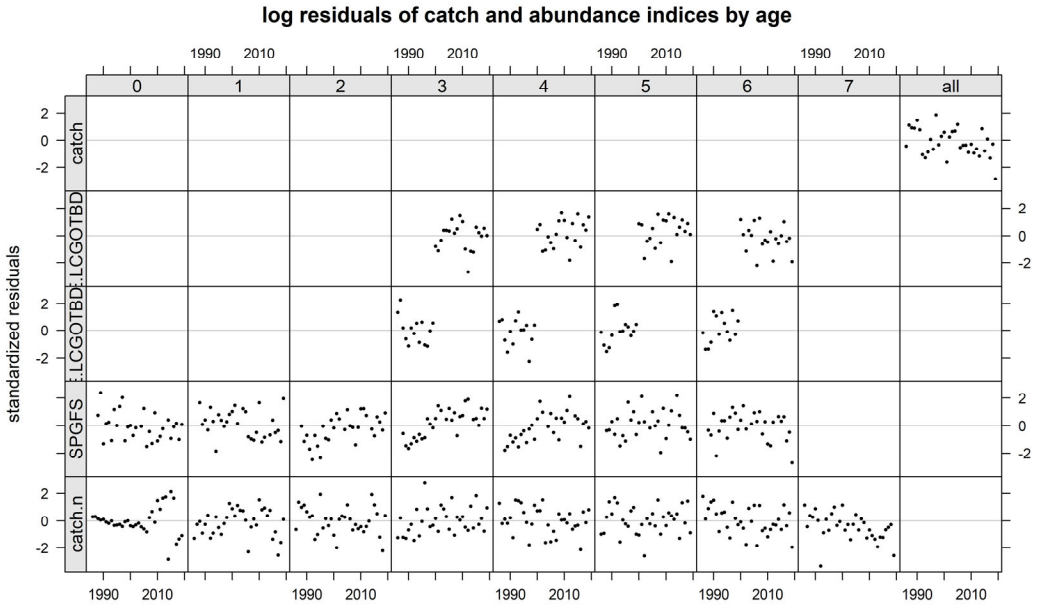


d. Retrospective pattern plots over the last 6 years

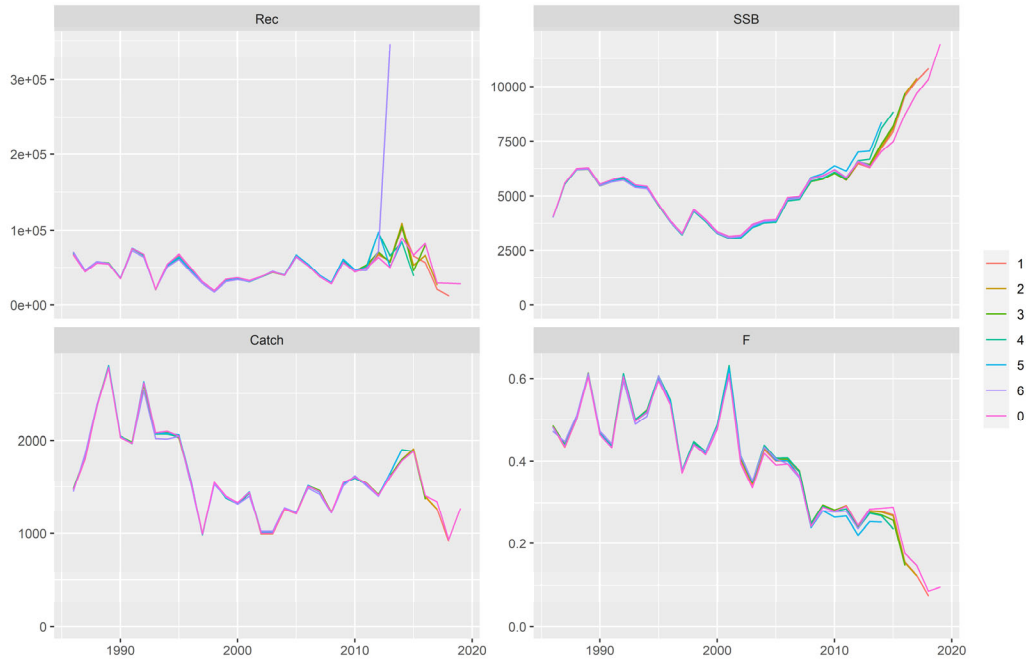
6.3 Fit 13: Adding a smooth term to age 0 in fishing mortality model and smooth terms in the catchability models for the survey and the commercial fleets.

The age 0 residual pattern in the catch is still not adequate. Smooth terms were added to the previous case in the catchability submodel of LPUEs.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 0))
qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3))
```



e. Log residuals of catch and abundance indices by age.

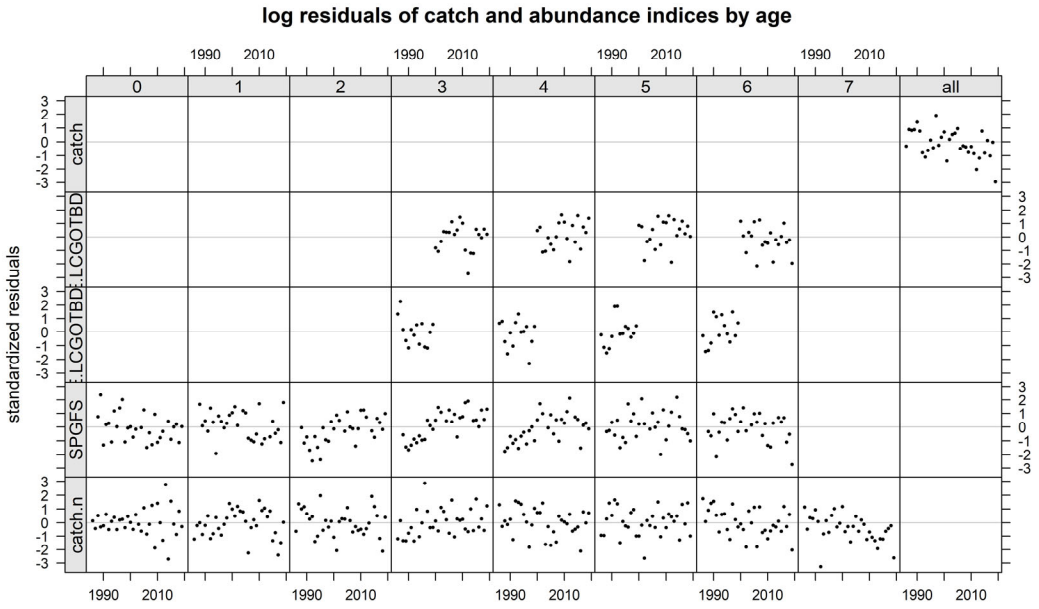


f. Retrospective pattern plots over the last 6 years

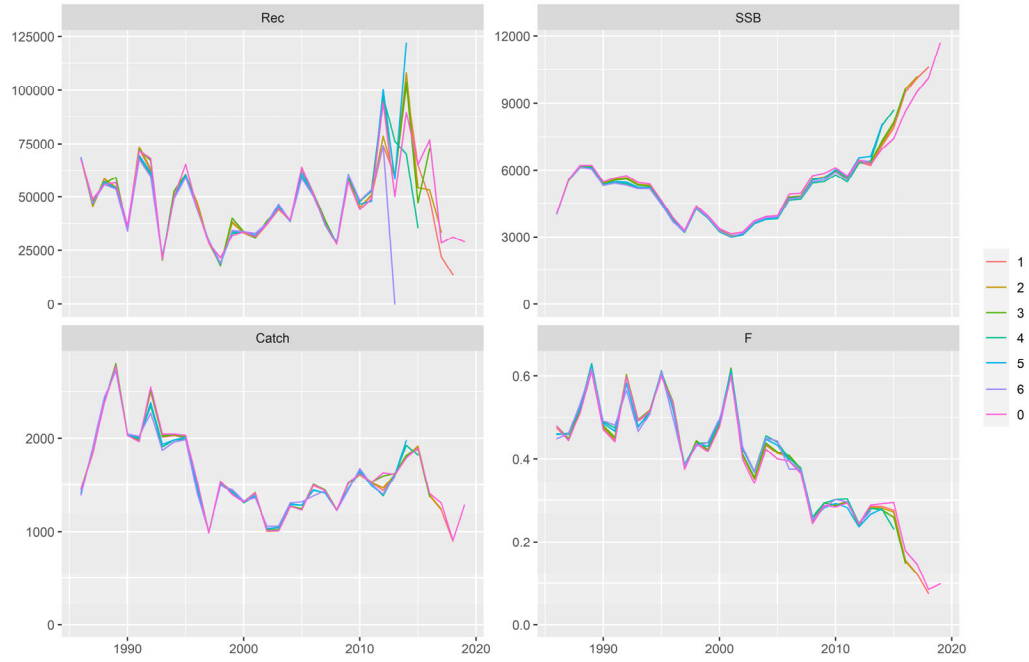
6.4 Fit 16: Increasing k value in the smooth term in the fishing mortality submodel.

In the last case presented, k value in the smooth term in the fishing mortality submodel was increased in relation to the previous one. This is aimed at trying to resolve issue residuals of age 0 in the capture.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 25, by = as.numeric(age == 0))
qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3))
```

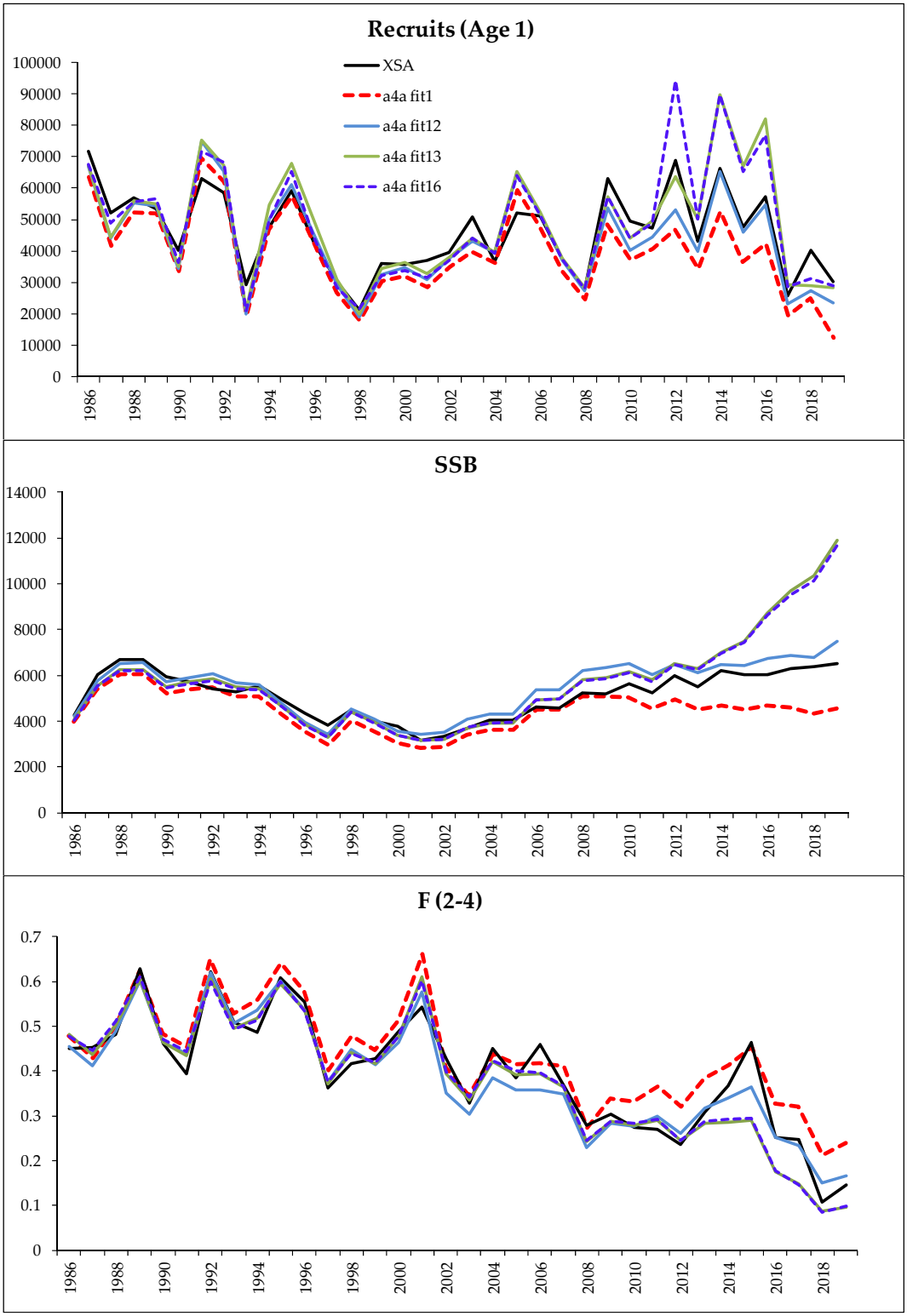


g. Log residuals of catch and abundance indices by age.



h. Retrospective pattern plots over the last 6 years

7 Comparison with the current assessment (XSA, 2020WGBIE)



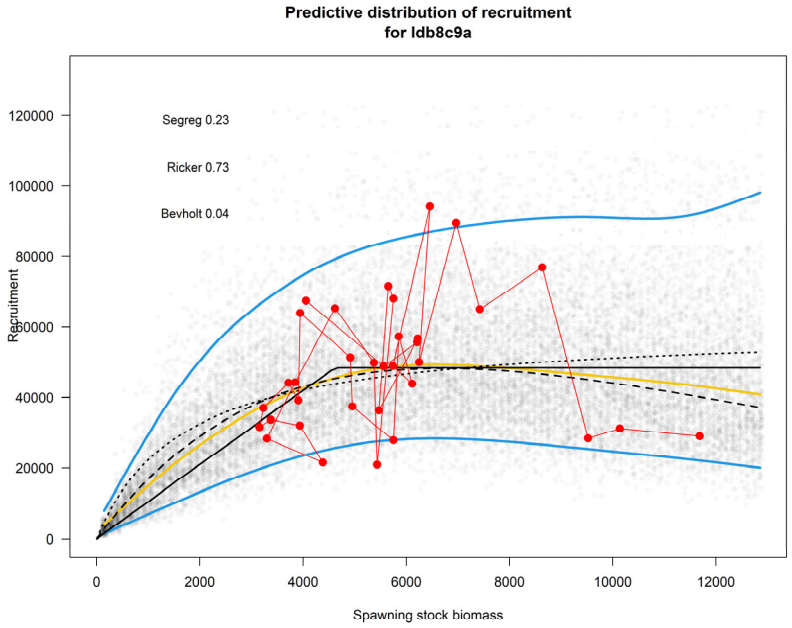
c. XSA Stock status estimates versus a4a estimates in the studied fits for *L. boscii*.

d. Table with AIC, BIC and Mohn's Rho values of the different fits.

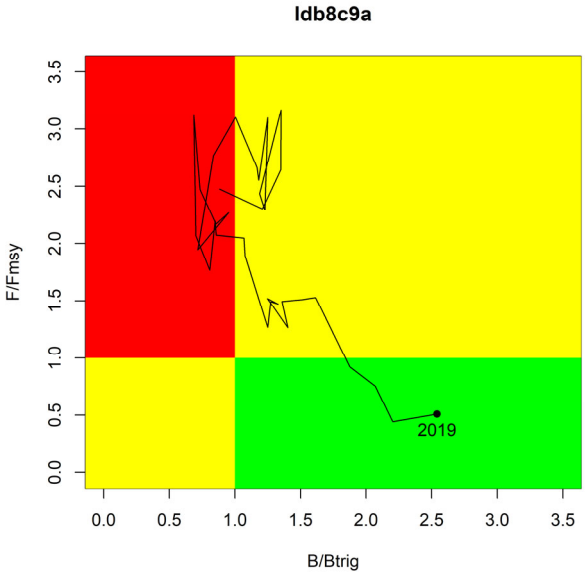
	AIC	BIC	Mohn's Rho (Retro_F)	Mohn's Rho (Retro_SSB)	Mohn's Rho (Retro_R)
XSA WG2020			-0.13	0.15	-0.11
Fit 1	1067.2	1459.5	0.101	0.042	-0.269
Fit 12	928.1	1348.6	0.085	-0.015	0.949
Fit 13	872.2	1310.5	-0.056	0.062	0.985
Fit 16	856.6	1392.2	-0.054	0.056	-0.050

8 Preliminary Biological Reference Points, forecast and Catch option table

Fit 16 was selected to obtain preliminary values. This selection was based on the best AIC, Mohn's Rho values and residuals.



d. Stock-Recruitment plot.



Btrigger	4385.8
Fmsy	0.161
Blim	3156.2
Bpa	4385.8
Flim	0.444
Fpa	0.32
lFmsy	0.113
uFmsy	0.263
F05	0.803

e. Kobe plot and BRP values.

f. Catch options table:

basis	catch	wanted	unwanted	F	Fwanted	Funwanted	SSB	ssbchange	advicechange
MSY approach: F[MSY]	2097	1963	134	0.161	0.151	0.072	9566	-17.4	11.3
F=MAP F[MSY lower]	1517	1421	96	0.113	0.106	0.051	10200	-11.9	-19.5
F=MAP F[MSY upper]	3212	3003	210	0.263	0.247	0.118	8353	-28	70
MSY approach: F[MSY]	2097	1963	134	0.161	0.151	0.072	9566	-17.4	11.3
F[mp]	2545	2381	164	0.2	0.188	0.09	9079	-22	35
F=0	0	0	0	0	0	0	11860	2.4	-100
F[pa]	3771	3522	249	0.32	0.3	0.144	7747	-33	100
F[lim]	4854	4525	329	0.444	0.417	0.2	6576	-43	158
SSB (2022)=B[pa]	6900	6406	494	0.756	0.71	0.341	4386	-62	270
SSB(2022)=B[lim]	8067	7465	602	1.015	0.953	0.457	3156	-73	330
SSB(2022)=MSY B[trigger]	7317	6785	531	0.839	0.788	0.378	3945	-66	290
F[2020]	1337	1253	84	0.098	0.092	0.044	10396	-10.2	-29
Roll-over TAC	1885	1765	120	0.143	0.134	0.064	9798	-15.4	0.00

9 Conclusion

The results for both stocks are promising and the work carried out shows that the a4a model is a strong candidate to be chosen for the assessments. Progress has been considerable and much work has been developed that would facilitate the change to the proposed model.

Many fits with different settings have been performed for the workshop. The residuals of the base case of the megrim did not present big issues, but the following configurations were made with a view to improving the AIC and Mohn's Rho values.

The four-spot megrim did need an improvement since its residuals had some patterns on the catch and the survey index at early ages. Several configurations were studied, reaching one that significantly improved the residuals.

Comparisons between fits done with the two models, XSA and a4a, show similar results with the same trends. Also the calculated BRPs and forecast for the selected ones during the WKTADSA do not differ by large amounts. The selected fits were fit 13 for *L. whiffiagonis* and fit 16 for *L. boscii*. The selection was base on best AIC, Mohn's Rho values and residuals.

From the selected settings the analysis can be adjusted in order to select the most suitable configurations for both stocks. Additional diagnostics can also be performed which would include prediction skill through retrospective prediction of model inputs and runs tests. As all the scripts are available and have been tested in different configurations, there is a lot of advanced work.

All of the above postulates that the a4a stock assessment model is adequate to leave a deterministic model and update the assessment of these two stocks.